Chapter 17

Northwest Sands Ecological Landscape






Where to Find the Publication

The Ecological Landscapes of Wisconsin publication is available online, in CD format, and in limited quantities as a hard copy. Individual chapters are available for download in PDF format through the Wisconsin DNR website (http://dnr.wi.gov/, keyword "landscapes"). The introductory chapters (Part 1) and supporting materials (Part 3) should be downloaded along with individual ecological landscape chapters in Part 2 to aid in understanding and using the ecological landscape chapters. In addition to containing the full chapter of each ecological landscape, the website highlights key information such as the ecological landscape at a glance, Species of Greatest Conservation Need, natural community management opportunities, general management opportunities, and ecological landscape and Landtype Association maps (Appendix K of each ecological landscape chapter). These web pages are meant to be dynamic and were designed to work in close association with materials from the Wisconsin Wildlife Action Plan as well as with information on Wisconsin's natural communities from the Wisconsin Natural Heritage Inventory Program.

If you have a need for a CD or paper copy of this book, you may request one from Dreux Watermolen, Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, WI 53707.

Photos (L to R): Blandings turtle, photo by Brian Collins; Karner blue butterfly, photo by Gregor Schuurman, Wisconsin DNR; Brewer's Blackbird, photo by Brian Collins; gray wolf, photo by John and Karen Hollingsworth, U.S. Fish and Wildlife Service; Short-eared Owl, photo by Jack Bartholmai.

Suggested Citation

Wisconsin Department of Natural Resources. 2015. *The ecological landscapes of Wisconsin: an assessment of ecological resources and a guide to planning sustainable management*. Wisconsin Department of Natural Resources, PUB-SS-1131 2015, Madison.

Suggested Citation for This Chapter

Wisconsin Department of Natural Resources. 2015. *The ecological landscapes of Wisconsin: an assessment of ecological resources and a guide to planning sustainable management*. Chapter 17, Northwest Sands Ecological Landscape. Wisconsin Department of Natural Resources, PUB-SS-1131S 2015, Madison.

Cover Photos

Top left: *This barrens has been restored and maintained by the use of prescribed fire and mechanical removal of woody cover. The prevalent tree here is northern pin oak; the flowering herb is wild lupine. Crex Meadows State Wildlife Area, Burnett County. Photo by Robert Hanson, Wisconsin DNR.*

Center left: *Soft-water seepage lake in sandy glacial outwash. Bayfield County. Photo by Eric Epstein, Wisconsin DNR.*

Bottom left: *The prairie skink inhabits barrens complexes and sparsely timbered oak woodlands in northwestern Wisconsin. Photo by A.B. Sheldon.*

Top right: *The Sharp-tailed Grouse requires large expanses of grasslands and barrens to maintain viable populations. The Northwest Sands Ecological Landscape has perhaps Wisconsin's best opportunity to support this declining species over the long-term. The individual pictured here is a displaying male. Wisconsin DNR file photo.*

Center right: *Several of Wisconsin's largest and most intact sedge meadows occur in the Northwest Sands Ecological Landscape. Numerous sensitive animals are dependent on such habitats. Crex Meadows State Wildlife Area, Burnett County. Photo by Eric Epstein, Wisconsin DNR.*

Bottom right: *Nelson's Sparrow is an exceedingly rare breeder in Wisconsin, but it has consistently inhabited the large, intact sedge meadows of the Northwest Sands. Photo courtesy of Andy Reago and Chrissy McClarren.*

Thomas Meyer, WDNR

Contents

LIST OF FIGURES

LIST OF TABLES


Thomas Meyer, WDNR

Northwest Sands Ecological Landscape at a Glance

Physical and Biotic Environment

Size

The Northwest Sands Ecological Landscape encompasses 1,956 square miles (1,251,723 acres), which is 3.5% of the area of the state of Wisconsin.

Climate

Mean annual temperature (41.30°F) is similar to other northern ecological landscapes. Annual precipitation averages 31.4 inches and annual snowfall about 61 inches, also similar to other northern ecological landscapes. The growing season is short and averages 121 days. Although there is adequate rainfall to support crops such as corn, the sandy soil and short growing season limit row crop agriculture, especially in the northern part of the ecological landscape.

Bedrock

Underlying bedrock at the southern edge of the Northwest Sands is Cambrian quartzose and glauconitic sandstone and siltstone. In the northern portion of the ecological landscape, the bedrock is Precambrian basalt, lithic conglomerate, shale, and feldspathic to quartzose sandstone. Bedrock is covered with 100 to 600 feet of glacial drift (sand, gravel, and silt), with the thickest deposits in the northern half. No terrestrial bedrock exposures are known from this ecological landscape.

Geology and Landforms

The Northwest Sands is the most extensive and continuous xeric glacial outwash system in northern Wisconsin. It has two major geomorphic components: a large outwash plain pitted with depressions, or "kettle lakes," and a former spillway of Glacial Lake Duluth (which preceded Lake Superior) and its associated terraces. The spillway is now a river valley occupied by the St. Croix and Bois Brule rivers. The hills in the northeast are formed primarily of sand, deposited as ice-contact fans at the outlet of subglacial tunnels. Lacustrine deposits (especially fine materials of low permeability such as clays) from Glacial Lake Grantsburg underlie Crex Meadows and Fish Lake Wildlife Areas and are responsible for impeding drainage, leading to the formation of the large wetlands there.

Soils

Upland soils are typically sands or loamy sands over deeper-lying strata of sand or sand mixed with gravel. These soils drain rapidly, leading to xeric, droughty conditions within the ecological landscape. Wetlands in low-lying depressions have organic soils of peat or muck.

Hydrology

This ecological landscape has significant concentrations of glacial kettle lakes, most of them seepage lakes, a well-developed pattern of drainage lakes, and several large wetland complexes. The lakes cover roughly 4.8% of the area of the Northwest Sands, the third highest percentage among ecological landscapes in Wisconsin. The headwaters of the St. Croix and Bois Brule rivers are here. Major rivers include the St. Croix, Namekagon, Yellow, and Totagatic. Springs and seepages are common along the upper Bois Brule River but are uncommon and local elsewhere.

Current Land Cover

Land cover is a mix of dry forest, barrens, grassland, and agriculture, with wetlands occupying significant parts of the bed of extinct Glacial Lake Grantsburg, kettle depressions, and some river valleys. Within the forested portion, pine, aspen-birch, and oak are roughly equally dominant. The maple-basswood, spruce-fir, and bottomland hardwood forest types occupy small percentages of the ecological landscape's forests. The open lands include a large proportion of grassland and shrubland. Emergent/wet meadow and open water are significant in the southern part of the Northwest Sands. There is very little row-crop agriculture.

Socioeconomic Conditions

The counties included in this socioeconomic region are Bayfield, Burnett, Douglas, and Washburn counties.

Population

The population was 90,541 in 2010, 1.6% of the state total.

Population Density
21 persons per square mile

Per Capita Income
$26,208

Important Economic Sectors
The largest employment sectors in 2007 were Government (18.7%), Tourism-related (15.8%), Retail trade (10.7%), and Health Care and Social Services (9.7%). Although forestry does not have a large impact on the number of jobs, it is the sector that has the largest impact on the natural resources in the ecological landscape.

Public Ownership
Forty-eight percent of the land and water in the Northwest Sands Ecological Landscape is in public ownership. Federal lands include parts of the Chequamegon-Nicolet National Forest and the St. Croix National Scenic Riverway. Important state-owned lands include Crex Meadows, Fish Lake, Amsterdam Sloughs, and Douglas County Wildlife Areas and parts of the Brule River and Governor Knowles State Forests. Extensive county forests are owned and managed by Bayfield, Burnett, Douglas, and Washburn counties. The Wisconsin DNR leases county land for the Namekagon Barrens Wildlife Area explicitly for barrens management. A map showing public land ownership (county, state, and federal) and private lands enrolled in the forest tax programs in this ecological landscape can be found in Appendix 17.K at the end of this chapter.

Other Notable Ownerships
The Wisconsin Chapter of The Nature Conservancy has developed conservation agreements with a number of persons owning land along and near the Brule River in Douglas County.

Considerations for Planning and Management
Lakeshore development has been occurring at a rapid rate, partly because of this ecological landscape's close proximity to the Minneapolis-St. Paul metropolitan area. The sandy soils are low in productivity and highly erodible, and great care must be taken when planning and conducting timber harvests and in using motorized recreational vehicles such as ATVs to avoid causing damage to slopes and fragile vegetation. Many rare plants and animals occur here, especially in the barrens and sedge meadow habitats, and these need consideration when planning and conducting management activities here. Increasing connectivity between patches of open or semi-open lands such as pine or oak barrens remnants and reducing habitat fragmentation and isolation are major management considerations for the Northwest Sands. Achieving greater connectivity between open habitats may be accomplished by the use of firebreaks, rights-of-way, pastureland, CRP, or other types of nonforested cover. There is typically sharp contrast ("hard edge") between the open, nonforested habitats and the surrounding dry forests. Identifying areas where some of this high contrast hard edge may be reduced is needed to plan for and provide greater structural variability in the dynamic barrens ecosystems and to better meet the needs of species not well adapted to either very open or densely canopied habitats. In recent years, there has been a great increase in the amount of land planted in pine plantations, usually at the expense of dry forest and barrens communities. Much of the vegetation here is dependent on periodic disturbance, especially via the use of prescribed fire. Some types of land disturbance can facilitate the colonization and spread of invasive plants. Leafy spurge and spotted knapweed are among the invasive plants currently posing serious problems in sandy uplands. Common reed is present in some open wetlands and may be increasing. Glossy buckthorn has been reported from the extensive northern white-cedar swamps along the upper Brule River.

Management Opportunities
The Northwest Sands is the best place in Wisconsin and, arguably, the planet to manage for the globally rare Pine Barrens community. Large-scale barrens management is possible here because of the ecological suitability of the land, the presence of numerous remnants, and substantial public ownership. There are opportunities to connect existing barrens remnants and restoration projects with corridors and manage them with a mosaic of compatible vegetation types. Prescribed fire and other management tools can be used to develop more diverse structural characteristics and to enhance or restore species composition in many pine-oak barrens communities.

Some of the state's best places to manage for dry forests of jack pine, northern pin oak, and red pine are found in this ecological landscape. There are also opportunities to manage for older dry-mesic white pine-red pine-red oak forests, in the rugged northern part of the ecological landscape, on the slopes above the Bois Brule River in Douglas County, along the St. Croix River in Burnett and Polk counties, and at scattered locations elsewhere.

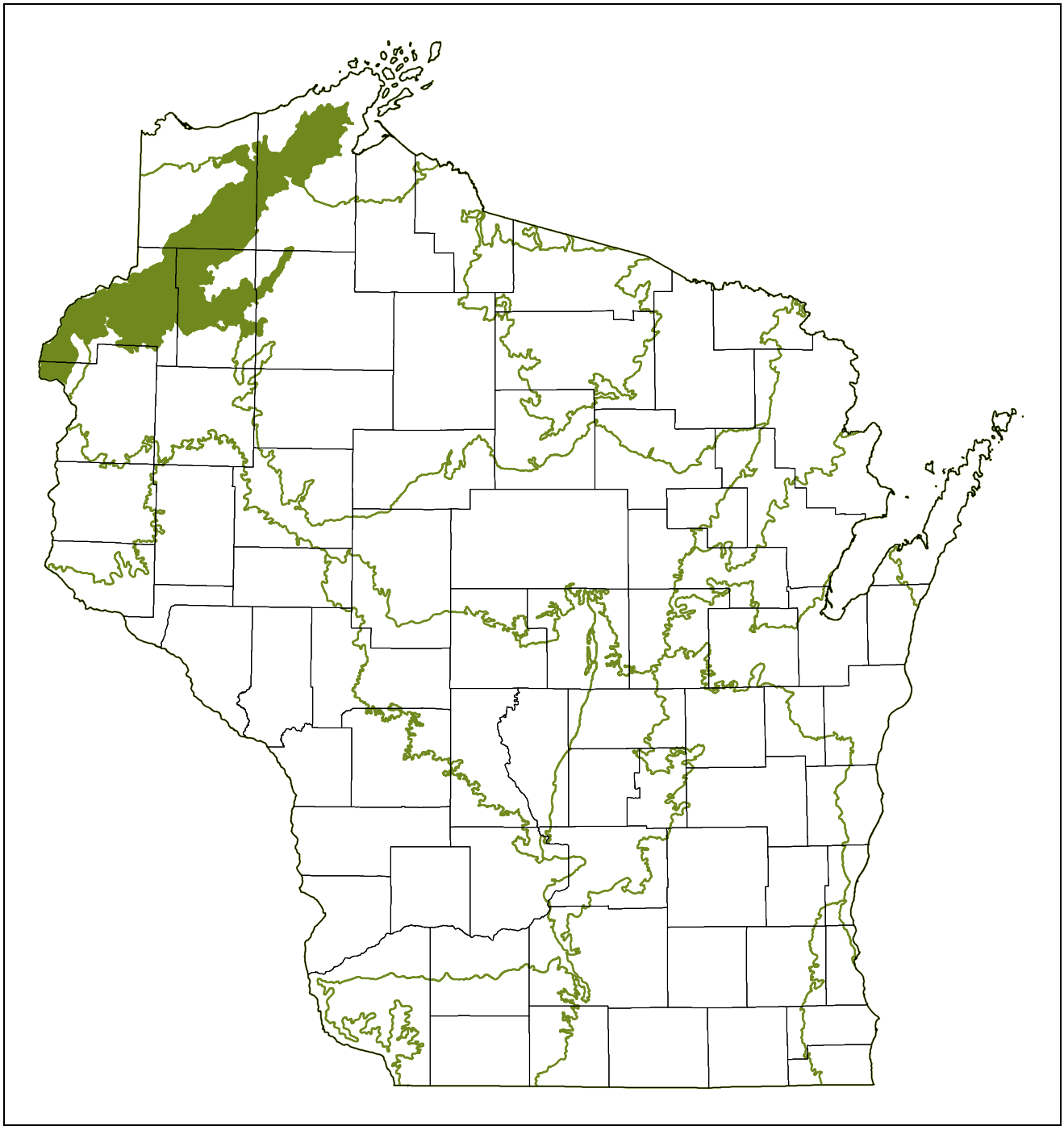
Wetlands are extensive, provide habitat for many sensitive species, and represent major management opportunities. The open meadows and marshes in the southwestern part of the Northwest Sands Ecological Landscape are particularly important because of their size, good condition, intact hydrology, and the presence of numerous habitat specialists. Some of the larger marshes are within the managed flowages at Crex Meadows and Fish Lake Wildlife Areas, and at Gordon on the St. Croix River. Acid peatlands of black spruce-tamarack swamp, muskeg, open bog, and poor fen are widespread and common, especially in areas of pitted outwash, where lakes and poorly drained kettle depressions are important landscape features.

The Northwest Sands harbors significant concentrations of glacial kettle lakes. Development pressures are high. The lakes provide high quality habitats for aquatic organisms, resident and migratory birds, and many other species. Inland Beaches are rare, localized, or absent in most of Wisconsin. Here, beach communities occupy the sand and gravel littoral zones of soft-water seepage lakes with upland shorelines and which experience naturally fluctuating water levels. There is a need to conduct an inventory of lacustrine and beach habitats to better determine their status and identify the best occurrences, management needs, and associated rare species populations. The protection of undeveloped lakes and associated high-quality habitats is a significant opportunity in the Northwest Sands.

The St. Croix, Namekagon, Totagatic, Bois Brule, and Eau Claire rivers warrant special attention because of their excellent water quality, exceptional aquatic biota, recreational opportunities, and aesthetic features. The north-south orientation of the St. Croix and Bois Brule rivers, along with the generally unfragmented condition of the forests bordering these rivers, makes them highly significant to migratory birds and probably to other species. The extensive northern white-cedar swamp along the upper Bois Brule River is among Wisconsin's best examples of that community type, supports numerous rare species, and merits strong protection. Excellent occurrences of alder thicket, springs and spring seeps, and spring ponds also occur along the upper Brule and present additional management and protection opportunities.

Solon Springs Sharp-tail Barrens is owned by Douglas County and managed to perpetuate an excellent example of the globally threatened Pine Barrens community. Numerous rare animals persist here and at a small number of other sites in the Northwest Sands Ecological Landscape. Photo by Thomas Meyer, Wisconsin DNR.

The Saint Croix-Namekagon River system supports a high diversity of aquatic life and offers excellent recreational opportunities. Photo by Eunice Padley, Wisconsin DNR.



Northwest Sands Ecological Landscape

J. Grahn

Northwest Sands Ecological Landscape

Introduction

This is one of 23 chapters that make up the Wisconsin DNR's publication *The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management*. This book was developed by the Wisconsin DNR's Ecosystem Management Planning Team and identifies the best areas of the state to manage for natural communities, key habitats, aquatic features, native plants, and native animals from an ecological perspective. It also identifies and prioritizes Wisconsin's most ecologically important resources from a global perspective. In addition, the book highlights socioeconomic activities that are compatible with sustaining important ecological features in each of Wisconsin's 16 ecological landscapes.

The book is divided into three parts. Part 1, "Introductory Material," includes seven chapters describing the basic principles of ecosystem and landscape-scale management and how to use them in land and water management planning; statewide assessments of seven major natural community groups in the state; a comparison of the ecological and socioeconomic characteristics among the ecological landscapes; a discussion of the changes and trends in Wisconsin ecosystems over time; identification of major current and emerging issues; and identification of the most significant ecological opportunities and the best places to manage important natural resources in the state. Part 1 also contains a chapter describing the natural communities, aquatic features, and selected habitats of Wisconsin. Part 2 of the book, "Ecological Landscape Analyses," of which this chapter is part, provides a detailed assessment of the ecological and socioeconomic conditions for each of the 16 individual ecological landscapes. These chapters identify important considerations when planning management actions in a given ecological landscape and suggest management opportunities that are compatible with the ecology of the ecological landscape. Part 3 of the book, "Supporting Materials," includes appendices, a glossary, literature cited, recommended readings, and acknowledgments that apply to the entire book.

This publication is meant as a tool for applying the principles of ecosystem management (see Chapter 1, "Principles of Ecosystem and Landscape-scale Management"). We hope it will help users better understand the ecology of the different regions of the state and help identify management that will sustain all of Wisconsin's species and natural communities while meeting the expectations, needs, and desires of our public and private partners. The book should provide valuable tools for planning at different ***scales***, including master planning for Wisconsin DNR-managed lands, as well as assist in project selection and prioritization.

Many sources of data were used to assess the ecological and socioeconomic conditions within each ecological landscape. Appendix C, "Data Sources Used in the Book" (in Part 3, "Supporting Materials"), describes the methodologies used as well as the relative strengths and limitations of each data source for our analyses. Information is summarized by ecological landscape except for socioeconomic data. Most economic and demographic data are available only on a political unit basis, generally with counties as the smallest unit, so socioeconomic information is presented using county aggregations that approximate ecological landscapes unless specifically noted otherwise.

Rare, declining, or vulnerable species and natural community types are often highlighted in these chapters and are given particular attention when Wisconsin does or could contribute significantly to maintaining their regional or global abundance. These species are often associated with relatively intact natural communities and aquatic features, but they are sometimes associated with cultural features such as old fields, abandoned mines, or dredge spoil islands. Ecological landscapes where these species or community types are either most abundant or where they might be most successfully restored are noted. In some cases, specific sites or properties within an ecological landscape are also identified.

Although rare species are often discussed throughout the book, "keeping common species common" is also an important

Terms highlighted in green are found in the glossary in Part 3 of the book, "Supporting Materials." Naming conventions are described in Part 1 in the Introduction to the book. Data used and limitation of the data can be found in Appendix C, "Data Sources Used in the Book," in Part 3.

consideration for land and water managers, especially when Wisconsin supports a large proportion of a species' regional or global population or if a species is socially important. Our hope is that this publication will assist with the regional, statewide, and landscape-level management planning needed to ensure that most, if not all, native species, important habitats, and community types will be sustained over time.

Consideration of different scales is an important part of ecosystem management. The 16 ecological landscape chapters present management opportunities within a context of ecological functions, natural community types, specific habitats, important ecological processes, localized environmental settings, or even specific populations. We encourage managers and planners to include these along with broader landscape-scale considerations to help ensure that all natural community types, ***critical habitats***, and aquatic features, as well as the fauna and flora that use and depend upon them, are sustained collectively across the state, region, and globe. (See Chapter 1, "Principles of Ecosystem and Landscape-scale Management," for more information.)

Locations are important to consider since it is not possible to manage for all species or community types within any given ecological landscape. Some ecological landscapes are better suited to manage for particular community types and groups of species than others or may afford management opportunities that cannot be effectively replicated elsewhere. This publication presents management opportunities for all 16 ecological landscapes that are, collectively, designed to sustain as many species and community types as possible within the state, with an emphasis on those especially well represented in Wisconsin.

This document provides useful information for making management and planning decisions from a landscape-scale and long-term perspective. In addition, it offers suggestions for choosing which resources might be especially appropriate to maintain, emphasize, or restore within each ecological landscape. The next step is to use this information to develop landscape-scale plans for areas of the state (e.g., ecological landscapes) using a statewide and regional perspective that can be implemented by field resource managers and others. These landscape-scale plans could be developed by Wisconsin DNR staff in cooperation with other agencies and nongovernmental organizations (NGOs) that share common management goals. Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 contains a section entitled "Property-level Approach to Ecosystem Management" that suggests how to apply this information to an individual property.

How to Use This Chapter

The organization of ecological landscape chapters is designed to allow readers quick access to specific topics. You will find some information repeated in more than one section, since our intent is for each section to stand alone, allowing the reader to quickly find information without having to read the chapter from cover to cover. The text is divided into the following major sections, each with numerous subsections:

- Environment and Ecology
- Management Opportunities for Important Ecological Features
- Socioeconomic Characteristics

The "Environment and Ecology" and "Socioeconomic Characteristics" sections describe the past and present resources found in the ecological landscape and how they have been used. The "Management Opportunities for Important Ecological Features" section emphasizes the ecological significance of features occurring in the ecological landscape from local, regional, and global perspectives as well as management opportunities, needs, and actions to ensure that these resources are enhanced or sustained. A statewide treatment of integrated ecological and socioeconomic opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management."

Summary sections provide quick access to important information for select topics. "Northwest Sands Ecological Landscape at a Glance" provides important statistics about and characteristics of the ecological landscape as well as management opportunities and considerations for planning or managing resources. "General Description and Overview" gives a brief narrative summary of the resources in an ecological landscape. Detailed discussions for each of these topics follow in the text. Boxed text provides quick access to important information for certain topics ("Significant Flora," "Significant Fauna," and "Management Opportunities").

Coordination with Other Land and Water Management Plans

Coordinating objectives from different plans and consolidating monetary and human resources from different programs, where appropriate and feasible, should provide the most efficient, informed, and effective management in each ecological landscape. Several land and water management plans dovetail well with *The Ecological Landscapes of Wisconsin*, including the Wisconsin Wildlife Action Plan; the Fish, Wildlife, and Habitat Management Plan; the Wisconsin Bird Conservation Initiative's (WBCI) All-Bird Conservation Plan and Important Bird Areas program; and the *Wisconsin Land Legacy Report*. Each of these plans addresses natural resources and provides management objectives using ecological landscapes as a framework. Wisconsin DNR ***basin*** plans focus on the aquatic resources of water basins and watersheds but also include land management recommendations referencing ecological landscapes. Each of these plans was prepared for different reasons and has a unique focus, but they overlap in many areas. The ecological management opportunities provided in this book are consistent with the objectives provided in many of these

plans. A more thorough discussion of coordinating land and water management plans is provided in Chapter 1, "Principles of Ecosystem and Landscape-scale Management."

General Description and Overview

The Northwest Sands Ecological Landscape is a large glacial outwash ecosystem consisting primarily of two major landforms: flat plains or terraces along glacial meltwater channels and ***pitted ("collapsed") outwash*** plains containing ***kettle lakes***. Soils are predominantly deep sands, low in organic material and nutrients. Other landforms and soils are found here but are of comparatively minor extent. This ecological landscape is comprised entirely of the Bayfield Sand Plains Subsection 212Ka of the Western Superior Uplands Section (Cleland et al. 1997), as shown on the Wisconsin Landtype Associations map in Appendix 17.K at the end of this chapter. (For details on Subsections, see the "Introduction" to this publication and the "Ecological Landscapes, NHFEU Provinces, Sections, and Subsections" map in Appendix G, "Statewide Maps," in Part 3, "Supporting Materials.").

Historical vegetation at the time of the federal General Land Office's public land survey (mid-1800s) was predominantly jack pine (*Pinus banksiana*) and "***scrub oak***" (*Quercus ellipsoidalis* and *Quercus* spp.) forest and barrens. Eastern white pine (*Pinus strobus*) and red pine (*Pinus resinosa*) forests were also a sizable vegetative component of the ecological landscape. Numerous barrens occurred in the southwest half, and a few large barrens occurred within the northeastern half. Most of the trees in the barrens were jack pine, but red pine savannas were present, and oak savannas occurred in the south central section.

Current vegetation is a mix of forest, grassland and barrens, and limited agriculture, with wetlands concentrated in the bed of Glacial Lake Grantsburg, in the kettles on pitted outwash landforms, and in the river valleys. Within the forested portion (approximately 76% according to 2004 Forest Inventory and Analysis data from the U.S. Forest Service; USFS 2004), pine, aspen-birch, and oak are roughly equally dominant (27% of the forested area each). The maple-basswood, spruce-fir, and lowland hardwood forest type groups occupy small percentages of the total forested area. Within the open lands, there is a relatively large proportion of grassland and shrubland, a small but significant amount of emergent/wet meadow and open water in the southern part of the Northwest Sands, and very little row-crop agriculture.

Several hundred kettle lakes occur in the pitted outwash plain. The headwaters of the St. Croix and Bois Brule river systems are located here amid rolling plains, sedge meadows, bog complexes, and major barrens. Water quality in seepage lakes is generally very good. Groundwater conditions are among the least polluted yet most vulnerable in the state.

Seventy-six percent of the Northwest Sands' 1.2 million acres is considered forestland (land with more than 17% canopy cover) in 2009 by Forest Inventory and Analysis (does not recognize barrens or other savannas) (USFS 2009). Forty-nine percent of ***timberland*** (forestland capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization) is under public ownership, while 51% is privately owned. The largest public landowners are the counties (28%), followed by federal (13%) and state (8%) governments.

The Northwest Sands counties have a low population density and an aging population. The population density of the four counties (21 persons per square mile) is about one-fifth that of the state as a whole (105 persons per square mile). Compared to other ecological landscape county approximations, the Northwest Sands counties have the second lowest percentage of people under 18, the third highest proportion of elderly (over 65) people, and the second highest median age among all of the state's ecological landscape county approximations. The American Indian population in the four counties is higher than the statewide average, while the percentage of other minority groups is below average.

The economy of the Northwest Sands counties is depressed when compared with the rest of the state. Per capita income and average wage are third lowest among the 16 ecological landscapes, and the rates of poverty and unemployment are third and fifth highest, respectively, among the state's ecological landscape county approximations. The government and services sectors are important employers in the four counties, whereas manufacturing is relatively unimportant.

Environment and Ecology

Physical Environment

Size

The total area within the Northwest Sands Ecological Landscape is 1,956 square miles (1,251,723 acres). This is 3.5% of the area of the state of Wisconsin, making it the sixth smallest ecological landscape in Wisconsin.

Climate

Climate data were analyzed from seven weather stations within the Northwest Sands Ecological Landscape (Brule Ranger Station, Hayward Ranger Station, Gordon, Grantsburg, Minong, Solon Springs, and Spooner Experimental Farm; WSCO 2011). This ecological landscape has a continental climate, with cold winters and warm summers, similar to other northern ecological landscapes. The northern ecological landscapes in Wisconsin generally tend to have shorter growing seasons, cooler summers, colder winters, and less precipitation than the ecological landscapes farther south. Ecological landscapes adjacent to the Great Lakes generally tend to have warmer winters, cooler summers, and higher precipitation, especially in the form of snow.

The growing season in the Northwest Sands Ecological Landscape averages 121 days (base 32°F), ranging from 98 to

142 days. This is the second shortest growing season of any ecological landscape in the state (the North Central Forest has the shortest growing season). Growing season length varied considerably among weather stations within the ecological landscape (by 44 days). Generally, weather stations farther north reported shorter growing seasons than weather stations farther south, but there were exceptions. It is notable that Grantsburg had 28 more growing degree days than the mean of the other weather stations in the ecological landscape (115 growing degree days). Grantsburg is the farthest southwest of any other weather station here.

The annual average temperature is 41.3°F (39.9–42.9°F), very similar to other northern ecological landscapes. Annual average temperature varied among weather stations by three degrees within the Northwest Sands, with the more northerly weather stations generally reporting lower temperatures than weather stations to the south. The average January minimum temperature is -2°F, and the average August maximum temperature is 80.4°F, similar to other northern ecological landscapes.

Annual precipitation averages 31.4 (29.6–33.5) inches, similar to the mean annual precipitation of other northern ecological landscapes (31.7 inches). Annual precipitation varied by almost 4 inches among weather stations within the ecological landscape, with Brule receiving the most precipitation (33.5 inches). Annual snowfall averages 61 inches (51.7–81.3 inches), similar to other northern ecological landscapes, excepting the Superior Coastal Plain, which is in the "snowbelt" of Lake Superior (87.4 inches). Snowfall in the Northwest Sands ranges from 51.7 inches in the south (Spooner) to 81 inches near Lake Superior (Brule).

Most of this ecological landscape is too far from Lake Superior to experience warming or cooling from the lake or to be affected by the amount of precipitation and snowfall caused by the lake. The one exception is the Brule weather station, which had higher amounts of precipitation, especially snowfall, than other weather stations within the Northwest Sands. Although there is adequate rainfall to support agricultural row crops such as corn, the sandy soil and short growing season limit row crop agriculture, especially in the northern part. The climate is favorable for supporting vegetation tolerant of low soil productivity and low tree cover such as dry forests and barrens, which cover more than 76% of the Northwest Sands.

Bedrock Geology

The Northwest Sands Ecological Landscape is primarily underlain by Precambrian sedimentary bedrock, along with some volcanic and metamorphic rock, in the Keweenawan Supergroup. A small portion in the southwest is underlain by Cambrian sandstone. See the map "Bedrock Geology of Wisconsin" in Appendix G, "Statewide Maps," in Part 3, "Supporting Materials." Precambrian rock consists mostly of sandstone but also includes basalt and other volcanic rocks. Bedrock is typically covered by 100 to 600 feet of glacial sediment, with the thickest deposits in the northern half (Ostrom 1983). Bedrock is so deeply buried by glacial materials that it does not directly influence the ecology of the ecological landscape. (Nomenclature used herein is according to the Wisconsin Geological and Natural History Survey Open-File Report *Bedrock Stratigraphic Units in Wisconsin;* WGNHS 2006.)

Keweenawan Supergroup rocks were formed during the Middle Proterozoic, making them the youngest Precambrian rocks in Wisconsin. They comprise a portion of the midcontinent rift system, formed at around 1.1 billion years ago, when the continent was nearly separated by volcanic eruptions in northwest Wisconsin and Upper Michigan. Lava flowed for approximately 20 million years, producing the basalt, rhyolite, and gabbro that are now exposed in the Penokee-Gogebic Iron Range in the North Central Forest Ecological Landscape and the Copper Range in Upper Michigan (Dott and Attig 2004). After the volcanic period, the crust slowly subsided due to the weight of the accumulated lava. The subsidence created a synclinal structure whose low-lying bowl is located beneath Lake Superior. Over millions of years, sediments of rivers and lakes accumulated in the basin. Then, at about 900 million years ago, a continental collision in eastern North America produced compressive forces that uplifted a section in the center of the rift, exposing the volcanic rocks of the Penokees and the Copper Range. In Duluth, high cliffs of basalt and gabbro form the area known as "Hawk Ridge" on the northwest side of the old continental rift. Rift structures can be detected in rocks beneath Lake Superior and have been traced in underground formations south to Kansas and east to Ontario near Lake Huron. See Dott and Attig (2004) and LaBerge (1994) for more detailed descriptions of the rifting and continental collision episodes.

Keweenawan volcanic rocks have been studied extensively where they are exposed in the uplifted portion of the rift, but the ones that lie deep beneath the Northwest Sands Ecological Landscape can differ because they were formed farther from the center of volcanic eruptions, with different flow sequences and cooling rates, and other types of crustal materials may have been incorporated into the lava (Wirth et al. 1998). Volcanic rocks underlying the southern part of the ecological landscape are sometimes known as the Chengwatana volcanics. Where they have been studied in Polk and Burnett Counties, they display varied patterns of magnetism and secondary mineral composition that differs from volcanic rocks exposed farther north (Wirth et al. 1998).

Thick layers of sedimentary rocks in the Keweenawan Supergroup, including sandstone, conglomerate, and shale, accumulated over the midcontinent rift volcanics during the subsidence period prior to the continental collision (Clayton 1984). These rocks formed from weathered volcanic materials between 1,050 and 1,110 million years ago are now the uppermost layers of bedrock in the portion of the rift system that was not uplifted in the continental collision. They are subdivided into the Oronto and Bayfield Groups; Oronto Group rocks are older. Formations within the Oronto Group include (from oldest to youngest) Copper Harbor Conglomerates,

Nonesuch Shale, and Freda Sandstone. The lowest formation, the Copper Harbor Conglomerates, conformably overlies Precambrian volcanic basement rock and is made up of volcanic rocks, pebble- to boulder-sized, embedded in coarse red-to-brown sandstone (Dickas 1992, LaBerge 1994). The Nonesuch Shale, a fine-grained black or gray rock formation about 460 feet thick, lies over the conglomerate and interfingers with it in many places. The copper mined at White Pine, Michigan, was found in the lower 20 feet of the Nonesuch Formation. This shale layer is also a potential source of hydrocarbons and has been the focus of industrial exploration over the past 30 years (Dickas 1992, LaBerge 1994). The uppermost rock of the Oronto Group is the Freda Sandstone, a thick deposit formed of a basal conglomerate that becomes finer upward in the sequence, changing to sandstone and siltstone (Dickas 1992).

Bayfield Group rocks are the Orienta, Devils Island, and Chequamegon formations, consisting of nearly flat-lying quartz sandstone deposited during the Late Proterozoic (Clayton 1984). These formations are thick (possibly more than 7,000 feet) and relatively uniform in composition, made up of about 99% sandstone and 1% shale. The Orienta and Chequamegon sandstones are red, with layers of shale and conglomerate. Devil's Island sandstone is buff to white in color and nearly pure quartzose (Dickas 1992, LaBerge 1994).

Based on the generalized statewide map of bedrock geology, about 41% of the ecological landscape is underlain by Oronto Group sandstones, 10% by Bayfield Group sandstones, 26% by volcanic and metamorphic rocks of the Keweenawan Supergroup, and 23% by Cambrian sandstones. The central part of the ecological landscape is almost entirely underlain by Oronto Group rocks. Bayfield Group rocks occur north of U.S. Highway 2, overlying the Oronto Group.

Landforms and Surficial Geology

The Northwest Sands Ecological Landscape formed in thick deposits of proglacial stream sediments overlying sandy loam till of the Copper Falls Formation. These materials were deposited by the Superior and Chippewa lobes during the Late Wisconsin glaciation between about 20,000 and 11,500 years ago (Clayton 1984). The sandy surficial materials, deposited from meltwater streams, make up the most extensive and continuous glacial outwash deposit in northern Wisconsin. The thickness of glacial deposits over bedrock typically ranges from around 50 to well over 100 feet.

The Superior and Chippewa lobes advanced as far south as the St. Croix and Chippewa Moraines in St. Croix, Polk, Barron, Rusk, Chippewa, and Taylor counties and then retreated and readvanced several times (Clayton 1984). Readvances included the Tiger Cat Advance, Hayward Advance, Swiss and Airport Advances, and the Lake Ruth Advance. Most of the sand deposited in the St. Croix valley originated from the Swiss and Airport Advances at about 14,000 to 12,000 years ago.

Surficial deposits are part of the Copper Falls Formation (Clayton 1984). Outwash and ice-contact sands overlie sandy loam till, but till is not exposed at the surface in the Northwest Sands. The till can be recognized quite easily in cut banks along rivers, where it is typically a reddish-brown sandy loam. It was derived through glacial action on the reddish Precambrian sandstone bedrock of the Keweenawan Supergroup in the Lake Superior basin and from meltwater deposits of proglacial streams. Copper Falls till forms most of the land surface in the Northwest Lowlands and also in the ecological landscapes to the south and east of the Northwest Sands. The Copper Falls till is only slightly calcareous.

Most of the meltwater-deposited landforms of the Northwest Sands are pitted outwash, with "kettles" that formed where ice blocks stranded during glacial retreat melted and left a depression in the surface (Figure 17.1). Lakes exist in some of these kettles where the water table is high due to underlying till that is less permeable. Some stream sediment was deposited on solid ground and has flat topography. A map of these landforms is included with Clayton's (1984) publication on Pleistocene geology of the area.

The Bayfield hills, located in the northeastern part of the Northwest Sands and adjacent areas of the Superior Coastal Plain, are sandstone-cored and covered by up to 500 feet of sandy sediment, possibly deposited as ice-contact fans at the

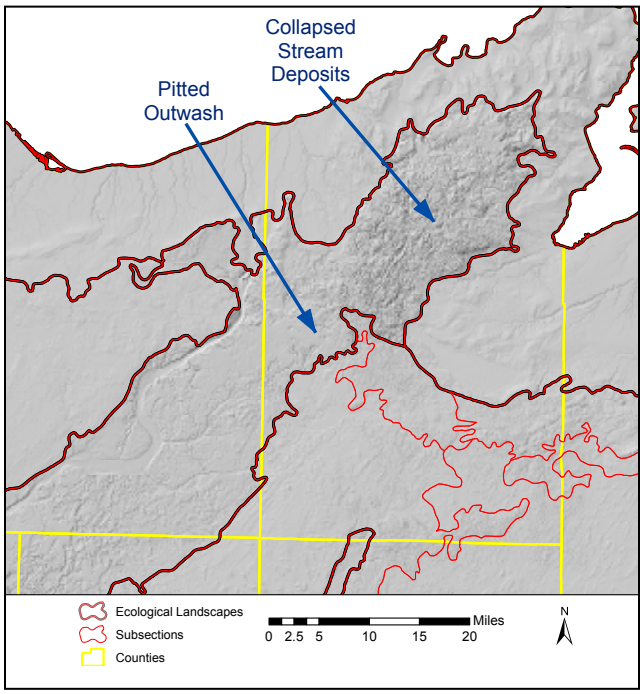


Figure 17.1. *The northern portion of the Northwest Sands exhibits hilly topography while much of the rest of the ecological landscape has the typically flat or gently undulating topography of an uncollapsed outwash plain. The rougher topography of the Bayfield Peninsula was formed by proglacial stream deposits overlain on stagnant glacial ice. As underlying ice melted, stream-deposited materials collapsed into the cavity. These differences in the physical environment allowed a forest of eastern white and red pine to predominate, while most of the rest of the ecological landscape was covered with jack pine and scrub oak forest and barrens.*

outlet of subglacial tunnels (Clayton 1984, Dott and Attig 2004). The surface of the hills was partially reworked by subsequent glaciation and by postglacial erosion and stream-cutting. Large hills built of sand are unusual features in Wisconsin, although there are sandy head-of-outwash hills in the Northeast Sands.

The St. Croix and the Bois Brule River valleys are major landscape features that occur along most of the northwestern boundary of the ecological landscape. This channel drained a number of glacial lakes that formed ahead of ice sheets whenever outlets at the east end of the Lake Superior basin were blocked by the glaciers. The large size of the valleys indicates that a considerable amount of flow was required to carve such a channel. Clayton (1984) thought it most likely that Glacial Lake Ontonagon in the western Upper Peninsula drained catastrophically at around 11,000 years ago (the end of the Porcupine Advance) when an ice dam melted and the lake breached the barrier. The rapidly draining lake flowed westward along the edge of the ice sheet, joining the Bois Brule valley just south of the current river crossing on U.S. Highway 2. Because the ice sheet blocked the Lake Superior basin, water running through the Bois Brule channel drained southward into the St. Croix valley and the Mississippi River. The quantity of water draining from Glacial Lake Ontonagon would have been large enough to cut the valleys now occupied by the St. Croix and Bois Brule rivers.

The St. Croix and Bois Brule valleys were outlets for Glacial Lake Duluth from approximately 9,600 to 9,900 years ago, when the water stood at elevations up to 1082 feet (the current elevation of Lake Superior is 603 feet) and drainages to the east were blocked by ice. Glacial Lake Duluth began as a small lake in front of the melting ice sheet and enlarged as the ice retreated eastward and exposed more of the Lake Superior basin. Eventually, Glacial Lake Duluth was more than a third the size of current Lake Superior (Martin 1965).

Glacial Lake Grantsburg existed in most of Burnett County, in the southwest portion of the ecological landscape, about 14,000 years ago. Lake Grantsburg formed when a sublobe of the large Des Moines Lobe advanced eastward from Minnesota, blocking the St. Croix valley north of St. Croix Falls and impounding glacial meltwater (Dott and Attig 2004). The lake existed for about 80 to 100 years (Johnson 2000). Afterward, much of the lacustrine surface was eroded or buried when outwash sediment from glacial lakes in the Lake Superior basin flowed through the St. Croix valley and built terraces along the river. Farther away from the spillway, some of the original clay- and silt-textured lakebed remains and is only thinly overlain by outwash. Lacustrine deposits underlie Crex Meadows Wildlife Area and are responsible for impeding drainage and leading to the formation of the large wetlands there. Another glacial lake, Lake Lind, existed at an even earlier stage and deposited the lacustrine materials that underlie Fish Lake Wildlife Area.

A map showing the Landtype Associations (WLTA Project Team 2002) in the Northwest Sands Ecological Landscape, along with the descriptions of the Landtype Associations, can be found in Appendix 17.K at the end of this chapter.

Topography and Elevation

The lowest elevation in the Northwest Sands Ecological Landscape is 764 feet (232 meters) at the Trade River near the southern boundary of the ecological landscape. Lower elevations generally occur throughout the southwestern part of the ecological landscape. Elevations rise into the Bayfield hills of northern Bayfield County. The highest elevation is 1,443 feet (440 meters) in the vicinity of the Lenawee Lookout in the Chequamegon-Nicolet National Forest in Bayfield County. Topography is nearly level in the southwestern portion of the ecological landscape, undulating or rolling in the central pitted outwash area, and hilly and steep in the northern portion.

Soils

Soil moisture holding capacity, nutrients, and organic material are low in most soils in the Northwest Sands Ecological Landscape. Upland soils on former glacial spillway terraces and pitted outwash plains are typically sands or loamy sands over deeper-lying strata of sand, or sand mixed with gravel. These soils drain rapidly, leading to xeric, droughty conditions. In the northern, hilly portion of the ecological landscape, soils have slightly loamier surface textures and higher nutrient and moisture availability.

Most upland soils formed in acid outwash sand. The dominant soil is excessively drained and sandy with a sand surface, very rapid permeability, and very low available water capacity. Overall, the soils range from excessively drained to somewhat poorly drained and generally have sand surface textures, rapid to very rapid permeability, and low available water capacity. A few morainal remnants occur within the ecological landscape, with soils formed in brown non-calcareous loamy sand till or mudflow sediments. They range from well drained to moderately well drained and generally have loamy sand to sandy loam surface textures, moderately rapid to slow permeability, and low to moderate available water capacity. An old glacial lake plain in the southern part of the ecological landscape has soils formed in gray calcareous lake sediment clay, some with a mantle of wind-blown sands. They range from poorly drained to somewhat poorly drained and generally have clay loam to fine sand surface textures, very slow permeability, and moderate available water capacity. Another significant area in the southern part of the ecological landscape has soils formed in acid outwash sand over reddish-brown non-calcareous clay lake sediment over acid outwash sand. These soils range from moderately well drained to somewhat poorly drained and generally have sand surface textures, rapid to very slow permeability, and low to moderate available water capacity. Most lowland soils are very poorly drained acid peat or non-acid muck. The major river valleys have soils formed in sandy alluvium or non-acid muck; drainage classes range from somewhat poorly drained to very poorly drained, and some areas are subject to periodic flooding.

The high permeability of these soils allows rapid infiltration and contributes to a relatively high risk of groundwater contamination from herbicides, fertilizers, and other biologically active compounds. Such substances should be used with caution in this ecological landscape. The use of off-road vehicles is a concern because of their impact on soils, particularly the downcutting of unimproved roads and trails, and surface displacement that leads to wind erosion. Large, open landscapes like the Northwest Sands are particularly attractive to off-road users, and the sensitive soils are subject to long-lasting damage.

Hydrology

Approximately 4.8% of this ecological landscape is open water of lakes, impoundments, rivers, and streams. This is the third highest percentage of open water among all of the ecological landscapes in the state. About 15.3% is covered in wetlands, classed as either forested, shrub, or emergent/wet meadow types (for details, see the "Wetlands" and "Current Vegetation" sections of this chapter). Seepage lakes are the most common type of lake here as they are in many parts of Wisconsin. Many of the shallower lakes support populations of wild rice (*Zizania* spp.). Major river systems include portions of the Namekagon, St. Croix, Totagatic, Brule, Yellow, and Clam rivers. With a relative lack of industrial discharges and agricultural nonpoint pollution, water quality here is generally good, which helps to maintain a healthy diversity of native aquatic communities and species.

Basins

The Northwest Sands Ecological Landscape partially overlaps several major watersheds (see the map entitled "Water Basins" in Appendix G, in Part 3, "Supporting Materials," to see how ecological landscapes relate to water basins). Most of the ecological landscape occurs within the St. Croix basin and ultimately drains to the Mississippi River. The northern portion, mostly within Bayfield County, is in the Lake Superior basin and drains to Lake Superior. Approximately 23% of this ecological landscape lies within the Lake Superior basin, roughly 75% lies within the St. Croix basin, and about 2% lies within the Upper Chippewa basin.

This ecological landscape was formed along the convergence of the Superior and Chippewa Glacial lobes. This resulted in an outwash plain characterized by deep sandy soils. These highly porous soils act like a sponge to rapidly absorb, store and later discharge groundwater to surrounding rivers, streams, and seepage lakes. The ecological landscape has concentrations of seepage lakes, a well-developed pattern of drainage lakes, and several large wetland complexes (see "Wetlands" section below). Invasive species have impacted vegetation, hydrology, and water quality in wetland and aquatic communities (see "Invasive Species" section).

Groundwater in the form of springs and seepages contributes significant flow to the St. Croix, Bois Brule, White, Onion, and Namekagon river systems. This water recharge characteristic of the Northwest Sands supports regionally important coldwater and coolwater fisheries. Low-gradient streams are relatively infrequent.

Inland Lakes

Lakes are abundant in portions of Bayfield, Burnett, Douglas, and Washburn counties within the Northwest Sands Ecological Landscape. According to Wisconsin DNR's 24K Hydrography Geodatabase (WDNR 2014b), there are 546 named lakes and 3,020 unnamed lakes, totaling 56,176 acres (almost all of these unnamed lakes are very small, lack ***navigable*** access, and would be defined in common terms as "ponds," but they often have important ecological values for aquatic invertebrates, waterbirds, herptiles, and many other aquatic species). Natural lakes are less common on the rougher terrain and deep sands of the Bayfield Peninsula.

A prominent cluster of larger lakes lies within a triangle formed by the St. Croix Flowage, Yellow Lake, and Spooner Lake. Sand, Pokegama, and many other popular recreational lakes north and west of Spooner form the heart of this lake region. Abundant game fish populations occur in many of these lakes and include walleye, muskellunge, and panfish.

The majority of lakes here are seepage lakes, the most common type of lake in Wisconsin. Seepage lakes have neither an inlet nor an outlet. They are fed primarily by precipitation

Inch Lake is an undeveloped, deep, soft-water seepage lake in Bayfield County. Photo by Mark Martin, Wisconsin DNR.

and overland flow (runoff) within their local drainage area, but they are sometimes supplemented by small amounts of groundwater input. Groundwater flows also supplement the water supply from the immediate drainage area that feeds seepage lakes. Since seepage lakes commonly reflect groundwater levels and rainfall patterns, water levels may fluctuate seasonally. The water levels of these "landlocked" lakes therefore fluctuate seasonally and annually with variations in precipitation and evaporation. Water level fluctuation cycles may last for periods of several years. The recent increase in shoreline development and associated infrastructure bears close watching for its impacts on water quality and vegetation. Water resources are one of the primary human attractions of the Northwest Sands.

Some of the shallow lakes here experience winter-kill conditions, affecting fish and some other aquatic life. However, these shallow lakes are often of high value to many species of wildlife and aquatic plants. There are 74 lakes and 30 ***stream segments*** and flowages with documented wild rice populations, especially northwest of Spooner (GLIFWC 2014b). The rice beds provide high value food for a variety of wildlife, including several species of waterfowl, rails, coots, and blackbirds. Many citizens also harvest wild rice for food and for its cultural significance.

Small lakes are now facing more intense development pressure as larger lake shorelines become more fully developed. Road density is typically high in areas with high lake density in order to provide access to property owners. Lakes experiencing heavy shoreline development can lead to loss of fish productivity, increased growth of nuisance weeds and algae, and loss of pollution-intolerant animal and plant species. These impacts result from increased impervious surface area yielding decreased groundwater infiltration and increased overland runoff, increased loadings of fertilizers from lawns, loss of native shoreline vegetation and other habitat, and increased soil disturbance and sedimentation from road and housing construction. Cranberry operations, though currently limited in the Northwest Sands, have the potential to decrease the amount of wetland habitat; alter structure, composition, and function of wetlands and aquatic communities; and affect local hydrology and water quality.

Local zoning and educational programs may help minimize human impacts. Lake districts and other organizations present opportunities for education, technical assistance, voluntary conservation, and acquisition to protect lake and river ***shorelands*** from the negative impacts of uncontrolled land development. However, the 2002 St. Croix basin plan noted that the lack of an updated and current lake water quality database makes it difficult to identify and deal with these problems in a systematic way. This basin plan contains a summary Lakes Report section that outlines the condition of 800 lakes in the basin, and many of those are in the Northwest Sands Ecological Landscape. These data include information on lake type, access, mercury advisories, trophic status, phosphorous sensitivity, and current or potential threats to lake health from a variety of factors. Future efforts to gather additional or updated information will rely heavily upon volunteers from local lakes groups.

All lakes in the Northwest Sands are classified under a county-wide lakes classification system adopted by each of the counties in the Northwest Regional Planning Commission service area (NWRPC and WDNR 2000). Such a system groups lakes within a given county according to physical, biological and/or cultural characteristics. Lake classification by counties is "intended to encourage the management of lakes and their watersheds on the basis of lake-specific characteristics" (LCAC 1999). Classification of lakes by counties is generally tied to management actions, such as lakeshed educational programs or shoreland and other zoning programs, in an attempt to protect lake water quality and aesthetics.

Impoundments

Drainage lakes owing one-half or more of their maximum depth to a dam are considered to be "artificial lakes," or impoundments. Dams influence the hydrological and biological characteristics of rivers and streams here as they do throughout Wisconsin. One hundred thirty-four dams remain that currently impound or otherwise modify the flow of streams in the Northwest Sands. Among these are six hydroelectric power dams in the St. Croix basin portion of this ecological landscape (WDNR 2002). These dams impound 29,587 acres of water surface and store a total volume of 103,822 acre-feet of water (WDNR 2014b); they include Gordon Flowage (1,913 acres), Minong Flowage (1,564 acres), and Phantom Flowage at Crex Meadows (1,480 acres). In addition, twenty-nine dams have been abandoned and removed from streams in this ecological landscape over the past several decades, including numerous dams removed from the Eau Claire and Totagatic river watersheds. The "Dams of the Northwest Sands" map in Appendix 17.K at the end of this chapter shows these and many other smaller dams as well as the sites of dams that have been removed or abandoned in compliance with Chapter 31, Wisconsin Statutes.

Drawdown of waterbodies with exposed muddy shorelines can be vulnerable to colonization by invasive plants, along with the desirable plant species that are used to attract waterfowl, shorebirds, and other species. Such sites should be monitored and care taken not to introduce invasive species.

Rivers and Streams

According to the Wisconsin DNR's 24K Hydrography Geodatabase (WDNR 2014b), at least 1,074 miles of perennial rivers and streams flow through the Northwest Sands Ecological Landscape. Major rivers and streams here include waters that maintain good water quality and a high degree of biological diversity. Several of these also attract high numbers of recreational users. These streams are the Namekagon River, from the Highway 63 bridge south of Cable downstream to the St. Croix; the St. Croix River from its source in southern Douglas County downstream to its confluence with the

Namekagon; the Yellow River from its source downstream to within a mile of the St. Croix; the lower half of the Totagatic River; and the upper ***reaches*** of the Bois Brule. Some of these river reaches flow along unprotected, privately held river frontage lands and are facing increasing development pressure as lake frontage prices increase.

The Wisconsin DNR Northern Rivers Initiative identified a number of streams as worthy of additional protection or other land use considerations. These streams include those named above and a number of lesser-known streams, all of which have high ecological significance, natural scenic beauty, and/or special recreational values. The St. Croix basin plan (WDNR 2002) identifies stream segments that are indicative of a relatively well-preserved, well-surveyed and biologically diverse aquatic environment and support rare aquatic species. These are the St. Croix from the Gordon Dam downstream for two river miles, the Namekagon River from Trego Dam downstream to Mackenzie Creek, and the Namekagon River from the Hayward Dam downstream for five river miles. The Clam River, a tributary to the St. Croix, supports a high concentration of rare invertebrate species.

Human activity significantly impacted some of the larger and medium-sized streams in this ecological landscape. In the late 19th and early 20th centuries, logging activity cleared streambanks and some entire watersheds of their forest cover, and subsequent fires destroyed regenerating trees and the duff layer. In all but the smallest reaches of a number of streams, loggers modified stream channels by removing abundant woody debris and building ***splash dams*** to provide water pulses to help float logs downstream. Logs scoured the bottoms of shallower streams, dislodging the gravel and woody substrates used by sensitive aquatic invertebrates and fish. This made many streams wider, shallower, less meandering, more subject to flash floods, and less able to sustain their native invertebrate and coldwater fish populations. Partial reforestation has reduced these impacts from their worst point in the 1920s, but some researchers estimate that flood peaks and sediment loads are still about twice their pre-Euro-American settlement levels (WDNR 2005b).

While fisheries enhancement programs have restored some stream habitat, western tributaries of the Bois Brule (Wilson, Nebagamon, and Blueberry creeks) and some upper reaches of the Iron River and Fish Creek may still reflect these influences. Logging in the riparian zone has limited the reestablishment of large woody debris in stream courses (WDNR 2001), but implementing ***best management practices*** and giving more attention to this and related issues in public lands management plans should promote the regrowth of large trees and other riparian vegetation and ultimately help to restore important structural elements to streams.

Roads can serve as introduction points for invasive species. Stream crossings that are not carefully designed and maintained can have significant negative impacts to water quality, floodwater flows, and the movement of aquatic organisms, including game fish.

Namekagon River, Douglas County. The Namekagon is within the St. Croix basin. Photo by Eric Epstein, Wisconsin DNR.

Spring-fed pond, marsh and sedge mat, embedded within extensive dry forest of pine, oak, and aspen. Barren Creek Springs, Burnett County. Photo by Eric Epstein, Wisconsin DNR.

Springs

Of the 10,864 springs documented in Wisconsin as of 2007, the Northwest Sands Ecological Landscape has 154 (Macholl 2007). This is the eighth highest number of springs among the 16 ecological landscapes. A number of these springs occur in the vicinity of the headwaters of the Bois Brule and Namekagon rivers. Groundwater is the primary source of water for spring lakes, flowing into the bottom of the lake from inside and outside the immediate surface drainage area. Spring lakes or ponds are the headwaters of many streams and are a fairly common type of lake in northern Wisconsin. The protection of groundwater quantity and quality (and therefore the protection of spring flows) is vital to the health of these lakes.

Wetlands

Mapped wetlands cover 191,436 acres, or 15.3% of the Northwest Sands Ecological Landscape, as estimated from current Wisconsin Wetlands Inventory (WWI) data (WDNR 2010c). The Northwest Sands Ecological Landscape contains

the tenth highest number of acres of wetlands and the ninth highest percentage of wetlands when compared to other ecological landscapes in the state. According to WWI, the most common wetland ***cover type*** is forested wetlands with 89,951 acres, followed by scrub/shrub wetlands with 71,155 acres. The emergent/wet meadow cover type totals 31,346 acres. A total of 2,871 acres of aquatic beds (aquatic plants growing entirely on or in a water body) occur in open water, predominantly in ponds, as well as in shallow lakes or shallow lake margins. No sphagnum bogs have yet been delineated here by WWI; however, field inventories conducted by the Natural Heritage Inventory program of the Wisconsin DNR's Bureau of Natural Heritage Conservation have documented numerous acid peatlands, all of which occur on a substrate of peat mosses (*Sphagnum* spp.). Four hundred eighty-four acres were classified as commercial cranberry bog, which can locally impact water quality and aquatic life through water level manipulations, thermal changes, and use of chemicals (Schreiber 1993, Greb et al. 1999, Fitzpatrick et al. 2003).

Many of the wetland types found in northern Wisconsin occur within the St. Croix watershed portion of the Northwest Sands Ecological Landscape (WDNR 2002). Most of the forested wetlands feature black spruce (*Picea mariana*), tamarack (*Larix laricina*), or swamp hardwood species such as black ash (*Fraxinus nigra*). Conifer swamps dominated by northern white-cedar (*Thuja occidentalis*) are not common, but there are several large occurrences with high ecological values because of their condition and the many rare species they support.

Additional information on wetlands and wetland flora may be found in the "Natural Communities" and "Flora" sections of this chapter and in Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin." Wetland management opportunities in the Northwest Sands are discussed in the "Management Opportunities for Important Ecological Features of the Northwest Sands Ecological Landscape" section below.

The upper Brule River is flanked by an unbroken corridor of wetlands, especially alder-dominated shrub swamp and conifer swamp. Brule River State Forest, Douglas County. Photo by Eric Epstein, Wisconsin DNR.

Water Quality

A large majority of the watersheds surveyed here have good water quality (see Appendix 17.A). Contributing factors include extensive forest cover and limited urban, industrial, and agricultural development. However, nearly the entire ecological landscape lies in an area mapped as having a high susceptibility to groundwater contamination because of the highly permeable soils.

Outstanding Resource Waters (ORW) and ***Exceptional Resource Waters (ERW)*** are surface waters that have good water quality, support valuable fisheries and wildlife habitat, provide outstanding recreational opportunities, and are not significantly impacted by human activities. Waters with ORW or ERW status warrant additional protection from the effects of pollution. Both designations have regulatory restrictions, with ORWs being the most restricted (see the glossary in Part 3, "Supporting Materials"). These designations are intended to meet federal Clean Water Act obligations and prevent any lowering of water quality or degrading of aquatic habitats in these waters. They are also used to guide land use changes and human activities near these waters. Numerous Outstanding and Exceptional Resource Waters occur within the Northwest Sands Ecological Landscape. A complete list of ORW and ERW in this ecological landscape can be found on the Wisconsin DNR website (WDNR 2014d).

Water quality remains good, in part, because a high percentage of land is undeveloped and in forest or other permanent cover. Much of it is in federal, state, county, and private industrial forest ownership. In addition, there is very little agriculture in the Northwest Sands (roughly 1%), although some lakes here (especially soft-water seepage lakes and other lakes that are naturally low in phosphorus) are highly susceptible to increased phosphorous loading from septic systems common to unsewered lakes. The Lake Superior Basin Water Quality Management Plan (WDNR 1999a) identifies several priority waters for assessment and protection of water quality. In the Upper Bois Brule watershed (LS04), these include Angel, Casey and Jerseth creeks, along with Hoodoo, Nebagamon, Rush, and Smith lakes. Several of these waters are wholly or partially within the Brule River State Forest. The Upper Chippewa River Basin Water Quality Management Plan (WDNR 1996) noted that Sand Lake in the Couderay River watershed (UC20) ranks as a priority lake due to phosphorous loading vulnerability.

Waters designated as impaired on the ***U.S. Environmental Protection Agency (EPA) 303(d) list*** exhibit various water quality problems, including ***polychlorinated biphenyls*** (PCBs) in fish, sediments contaminated with industrial metals, mercury from atmospheric deposition, bacteria from farm and urban runoff, and habitat degradation. Since the 303(d) designation is narrowly based on the criteria noted above, a waterbody could be listed as a 303(d) water as well as a ORW or ERW. These designations are not mutually exclusive. A plan is required by the EPA on how 303(d) designated waters will be improved by the Wisconsin DNR. This designation is used as

the basis for obtaining federal funding, planning aquatic management work, and meeting federal water quality regulations.

Many lakes in the ecological landscape have mercury levels from atmospheric deposition that are high enough to warrant fish consumption advisories, including three of the largest: Yellow Lake, St. Croix Flowage, and Minong Flowage (WDNR 2009a). Several lakes have specific advisories against eating any amount of certain kinds of fish, especially larger game species. The complete list of 303(d) impaired waters and criteria can be viewed at the Wisconsin DNR's impaired waters web page (WDNR 2010a).

Biotic Environment

Vegetation and Land Cover

Historical Vegetation

Several sources were used to characterize the historical vegetation of the Northwest Sands, relying heavily on data from the federal General Land Office's public land survey (PLS), conducted in Wisconsin between 1832 and 1866 (Schulte and Mladenoff 2001). PLS data are useful for providing estimates of forest composition and tree species dominance for large areas (Manies and Mladenoff 2000). Finley's map of historical land cover based on his interpretation of PLS data was also consulted (Finley 1976). Additional inferences about vegetative cover were sometimes drawn from information on land capability, climate, disturbance regimes, the activities of native peoples, and from various descriptive narratives. More information about these data sources is available in Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials." Finley's interpretation of PLS data describes the Northwest Sands as mostly covered with barrens and dry forests of jack pine and scrub oak (Figure 17.2). Finley noted that jack pine barrens occurred historically in Douglas, Bayfield, Polk, Burnett, Barron, Washburn, and Sawyer counties (Finley 1976). Finley noted a "dense growth of jack pine" in central Burnett and Washburn counties to the south and southeast of the described pine barrens. Sizable eastern white and red pine forests also occurred in the hills of Bayfield County in the northeastern part of the ecological landscape.

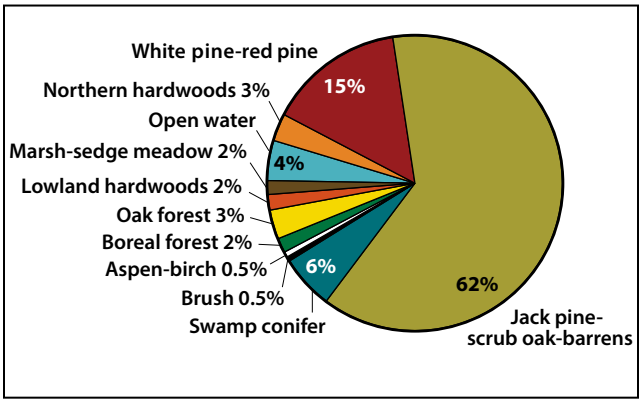


Figure 17.2. *Vegetation of the Northwest Sands Ecological Landscape during the mid-1800s, as interpreted by Finley (1976) from the federal General Land Office public land survey information.*

In recent years, PLS data have been converted to a GIS database, providing more detailed information about forest conditions in the 1800s. Analyses have shown that the General Land Office surveyors' methods provided accurate estimates of forest composition and dominance of tree species for large landscapes (Manies and Mladenoff 2000). Importance values for tree species were calculated based on density and ***basal area***. Jack pine was the most important tree (31%), followed by red pine (29%), eastern white pine (17%), oaks (*Quercus* spp.) (6%), tamarack (5%), aspen (*Populus* spp.) (4%), and white birch (*Betula papyrifera*) (3%). Maps showing the relative spacing of trees indicate that numerous barrens occurred in the southwest half of the ecological landscape, with a few large barrens in the northeastern half (Radeloff et al. 1998). A small number of these barrens were treeless over an area of a quarter-section or more, but most contained scattered trees spaced about 150 to 1500 feet apart. Most of the trees in the barrens were jack pine, but oak savannas likely existed in the south central part of the ecological landscape. (See the map "Vegetation of the Northwest Sands in the Mid-1800s" in Appendix 17.K the end of this chapter.)

Current Vegetation

There are several data sets available to help assess current vegetation on a broad scale in Wisconsin. Each was developed for different purposes and has its own strengths and limitations in describing vegetation. For the most part, WISCLAND (Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data), the Wisconsin Wetlands Inventory (WWI), the U.S. Forest Service's Forest Inventory and Analysis (FIA), and the National Land Cover Database (NLCD) were used. Results among these data sets often differ because they are the products of different methodologies for classifying land cover, and each data set was compiled based on sampling or imagery collected in different years, sometimes at different seasons, and at different scales. In general, information was cited from the data sets deemed most appropriate for the specific factor being discussed. Information on data source methodologies, strengths, and limitations is provided in Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials."

The Northwest Sands is approximately 1,251,723 acres in size, of which approximately 67% was forested in 1992 (Figure 17.3) (WDNR 1993). WISCLAND land use/land cover data also indicates that only 1% of the ecological landscape was in agricultural use at that time.

The Wisconsin Wetlands Inventory identifies wetlands by interpreting aerial photographs, offering a more detailed assessment than the WISCLAND data, which comes from the interpretation of satellite imagery. According to the Wisconsin Wetlands Inventory, wetlands occupy a relatively large portion of the Northwest Sands, comprising 15.3%, or approximately 191,000 acres of this ecological landscape's vegetation (WDNR

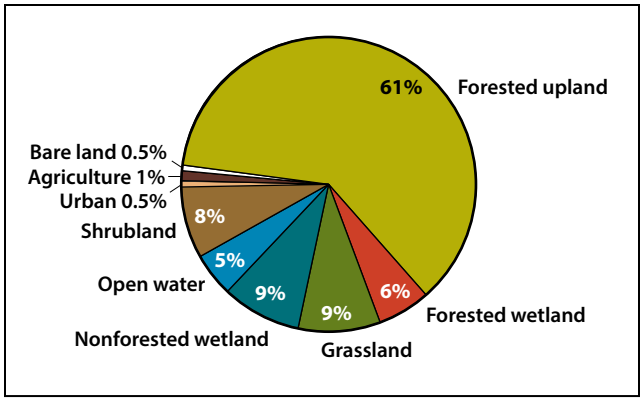


Figure 17.3. *WISCLAND land cover data showing categories of land use classified from 1992 LANDSAT satellite imagery for the Northwest Sands Ecological Landscape (WDNR 1993).*

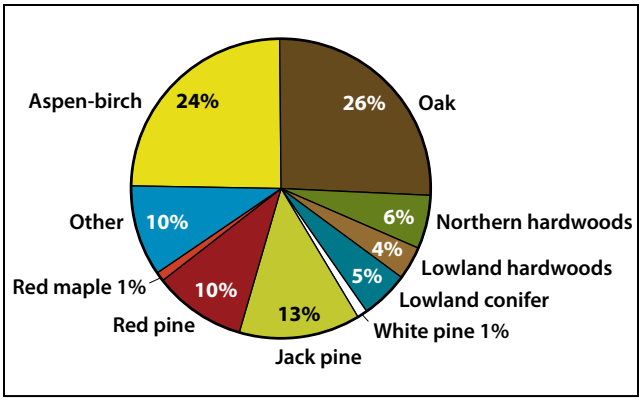


Figure 17.4. *Forest Inventory and Analysis data (USFS 2004) showing forest types as a percentage of forested land area (greater than 17% canopy cover) for the Northwest Sands Ecological Landscape.*

2010c). Forested wetlands make up nearly 86,000 acres of the ecological landscape, making these the most abundant wetland types in the Northwest Sands. Shrub/scrub wetlands occur across approximately 71,000 acres. Wet meadows (which include emergent marsh, sedge meadow, and poor fen communities) occupy approximately 31,000 acres.

Additional information on wetlands and wetland flora may be found in the "Natural Communities" and "Flora" sections of this chapter, and in Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," in Part 1 of the book.

In the forested area pine, aspen-birch, and oak forests are about equal in dominance: pines cover 24%, aspen-birch covers 24%, and oak-dominated forest type groups occupy 26% (USFS 2004). The maple-basswood, spruce-fir, and lowland hardwood forest type groups occupy only small percentages of the ecological landscape (Figure 17.4). Of the pine types, jack pine and red pine are represented in similar amounts, but there is almost no eastern white pine. Oak and aspen are now the major forest types found here.

Changes in Vegetation over Time

The purpose of examining historical conditions is to identify ecosystem factors that formerly sustained species and communities now altered in number, size, or extent or that have been changed functionally (for example, by constructing dams or suppressing fires). Although data are limited to a specific snapshot in time, they provide valuable insights into Wisconsin's ecological capabilities. Maintaining or restoring some lands to more closely resemble historical systems and including some structural or compositional components of the historical landscape within actively managed lands can help conserve important elements of native biological diversity. Information on the methodologies, strengths, and limitations of the vegetation change data is provided in Appendix C, "Data Sources Used in the Book," in Part 3.

A comparison of relative importance values (average of relative dominance [basal area] and relative density) of tree

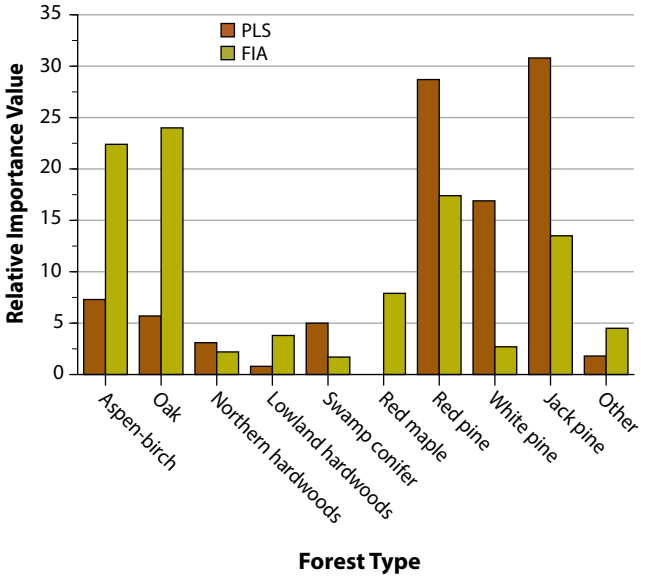


Figure 17.5. *Comparison of tree species' relative importance value (average of relative dominance and relative density) for the Northwest Sands during the mid-1800s, when federal General Land Office public land survey (PLS) data were collected, with 2004 estimates from Forest Inventory and Analysis (FIA) data (USFS 2004). Each bar represents the proportion of that forest type in the data set (totals equal 100 but include forest types only). Trees of less than 6-inch diameter were excluded from the FIA data set to make it more comparable with PLS data. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information about the PLS and FIA data.*

species represented in the PLS data with that of FIA data from 2004 shows that within the Northwest Sands, conifers such as eastern white pine, red pine, and jack pine have decreased in dominance (Figure 17.5). On the other hand, broad-leaved deciduous species such as oak, aspen, and red maple (*Acer rubrum*) have increased.

Information on the extent of open land prior to Euro-American settlement is not available, but federal public land survey tree density data can be compared to other ecological

Table 17.1. *Average density of tree coverage within the ecological landscapes of Wisconsin in the mid-1800s, from federal public land survey data, in trees per acre.*

Ecological landscape	Density (trees/acre)
Southwest Savanna	2.8
Central Sand Hills	4.4
Southern Lake Michigan Coastal	5.0
Southeast Glacial Plains	5.0
Western Coulees and Ridges	5.8
Northwest Sands	10.5
Central Sand Plains	11.0
Western Prairie	13.5
Northern Highland	57.0
Northeast Sands	62.2
Forest Transition	72.6
Northwest Lowlands	87.5
Superior Coastal Plain	122.8
North Central Forest	127.1
Central Lake Michigan Coastal	130.7
Northern Lake Michigan Coastal	144.6

landscapes (Table 17.1). The Northwest Sands had an average absolute density of 10.5 trees per acre, typical of the more open ecological landscapes. Many ecologists would classify such vegetation as savannas/barrens rather than forests. This is a density greater than that of Wisconsin's most treeless ecological landscape, the Southwest Savanna (2.8 trees per acre), but far less than that of the other, more heavily forested northern ecological landscapes such as the Northern Lake Michigan Coastal (144.6 trees per acre).

The big changes involving trees are the great reductions in the amount of pine (all three native species) with somewhat corresponding increases for broad-leaved deciduous species, especially the oaks, quaking aspen (*Populus tremuloides*), and red maple. In addition to the loss of pine, much of the land currently supporting pine, especially red pine, is plantation-grown. Natural forests or barrens in which red pine is dominant are now very rare.

Structurally, many of the large areas historically kept in an open or semi-open condition by periodic wildfire now support dense forests, with loss or suppression of native plants and animals that required more open conditions. Barrens restoration has been a major goal on federal, state, and some county lands within the Northwest Sands.

Wetlands remain in generally good condition. Some of the larger wetlands in the southwestern part of the ecological landscape had been altered by past ditching but have been partially restored via dikes and other water control structures.

Natural Communities

This section summarizes the abundance and importance of major physiognomic (structural) natural community groups in this ecological landscape. Some of the exceptional opportunities, needs, and actions associated with these groups or with some of the individual natural communities are discussed briefly. For details on the composition, structure, and distribution of the specific natural communities found in the Northwest Sands, see Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," in Part 1. Information on nonnative and invasive species can be found in the "Natural and Human Disturbances" section of this chapter.

Fire-adapted, and to some degree, fire-dependent, vegetative communities are a major feature of the Northwest Sands. Historically, fire was prevalent, due to permeable sandy soils, areas of nearly level topography, and extensive areas over which wildfires could run unimpeded. As a result, fire-adapted vegetation was abundant. Today this is best expressed in the varied structural permutations of the Pine Barrens community and in the extensive dry forests composed mostly of the fire-adapted pines and oaks. The clusters of seepage lakes, kettle bogs and other acid peatlands, wet meadows and marshes, and the major river corridors are also highly significant and representative features of this ecological landscape and constitute major conservation opportunities.

Forests

The cessation of frequent wildfires in the first half of the 20th century promoted the development of dense forests of jack pine, red pine, northern pin oak (*Quercus ellipsoidalis*), bur oak (*Quercus macrocarpa)*, and quaking aspen. These forests quickly covered many of the more open portions of the Northwest Sands, and as a result, the Northern Dry Forest community is now widespread and common here. The oaks increased in prominence especially rapidly, probably because they had been there all along in suppressed states as "grubs." Aspens (and white birch) were also well adapted to take advantage of the cut-over and burned-over lands. Red pine—because of its size, timber value in a landscape with

Dry forests dominated by oaks, especially northern pin oak, are now common in much of the Northwest Sands Ecological Landscape. Photo by Jerry Bartelt, Wisconsin DNR.

*The Whip-poor-will (*Antrostomus vociferus*) has declined in many parts of Wisconsin but is holding on in some of the more open, dry forests of Wisconsin's sandy regions. Photo by Jack Bartholmai.*

relatively few large trees of other species, and generally easy accessibility—was often completely removed by the settlers and loggers, leaving no seed source by which it could reestablish populations. Seedlings and small trees were destroyed by the fires that often followed tree removal.

Historically, dry forests that were composed primarily of red pine were probably maintained by relatively infrequent fires of low intensity. Severe stand-replacing fires would likely have occurred at intervals measured in centuries rather than decades. Natural red pine forests are presently rare throughout Wisconsin and in the Northwest Sands and continue to decline.

In areas historically dominated by jack pine, severe wildfires sometimes followed infestations of jack pine budworm (*Choristoneura pinus*). The fires, fueled by the abundance of dead and dying pines, burned unabated through the damaged stands. Heat from the flames opened the jack pine cones, releasing seeds that then found ideal conditions in which to germinate and grow (neither red nor eastern white pines produce cones with the capability of doing this). Fire suppression has altered this cycle. The distribution of jack pine forests was historically patchy, and at the landscape level many age classes were probably present.

Researchers believe jack pine budworm infestations have been made worse by jack pine planted by the Civilian Conservation Corps (CCC) in the late 1930s, which are all of the same age. In recent years, salvage harvests have often followed, or sometimes preceded, budworm infestations in the damaged or vulnerable stands. Many such sites were then converted to red pine plantations, as were many abandoned fields from failed farms. This conversion to monotypic pine plantations has significantly diminished the acreage of jack pine forest, reduced the compositional and structural variability of future stands, and altered the size of vegetation patches. Site preparation that includes ***furrowing*** and herbicide application can aggravate this situation and may increase the risk of invasive plant infestations. Managing jack pine forests in patches that emulate the landscape patterns and age-class structure created by natural fire disturbances may help reduce the magnitude of outbreaks of the jack pine budworm.

The jack pine forests of northwestern Wisconsin constitute an important stronghold for the Connecticut Warbler (*Oporornis agilis*), a Wisconsin Special Concern species, and there is potential for the establishment of a breeding population of the U.S. Endangered Kirtland's Warbler (*Setophaga kirtlandii,* listed as *Dendroica kirtlandii* on the Wisconsin Natural Heritage Working List; WDNR 2009b). In part because jack pine is a short-lived disturbance-adapted species that occupies a given site for a single generation of trees, the conservation value of Northern Dry Forest has been given relatively little attention until recently.

Because of its relatively short lifespan and adaptations to relatively frequent stand-replacing disturbance events, concerns for the representation of older successional stages have not been applied to jack pine or other dry forest communities as often or with as much vigor as they have to forests composed of longer-lived species. Consequently, intact examples of later dry forest successional stages are now very rare in this ecological landscape. Though ***old-growth forest*** was less prevalent here than elsewhere in northern Wisconsin, the absence of older forest of appropriate types on appropriate sites means that habitat for some plants and animals will be diminished or absent. Important structural and functional attributes of older jack pine forest will continue to be conservation concerns.

The Northern Dry-mesic Forest community occurs at scattered locations throughout this ecological landscape but is less abundant than the dry forest type. Dry-mesic forests are best developed where soil moisture and nutrient availability are more favorable to the growth of large trees than on the coarser, droughty sands that are prevalent over much

In Wisconsin the Connecticut Warbler is associated with dry forests dominated by dense stands of older jack pine. Photo by Dennis Malueg.

of the Northwest Sands. Natural firebreaks such as lakes and streams historically helped determine the distribution and abundance of this type. For example, in the rough rolling topography of the Bayfield Peninsula, both eastern white and red pines were well represented in the historical forests, and remnants of these cover types still occur there. Intact older stands are now rare, restricted to small patches at only a few sites, mostly on state or federal lands, but with at least a few on private holdings.

Although the Northern Wet-mesic Forest community is uncommon here, the extensive seepage swamps of northern white-cedar, black ash, black spruce, and tamarack that border the steep-sided valleys of the lower Bois Brule and upper St. Croix rivers have a unique geological history. These rivers were once connected. About 10,000 years ago, the valleys occupied by the present streams formed a spillway for proglacial lakes in the Lake Superior basin. The ecological values of the unusual forests that later developed in and along the margins of this "glacial spillway" are exceptionally high and include their overall intact and connected condition, the high number of associated rare plant and animal species, and the numerous springs and seepages that contribute cold, clean, oxygenated water to the rivers and create microsites that support many habitat specialists. They also contribute to maintaining relatively stable water levels by slowly releasing snowmelt and excess water from heavy precipitation events to reduce peak flows and help protect water quality by the filtration of nutrients and sediment. As in almost all other parts of Wisconsin, northern white-cedar reproduction here is very poor, creating concern for the long-term viability of this biologically rich community, which has many unique attributes in this region.

Older conifer swamp of tamarack, black spruce, white spruce, northern white-cedar. Brule River State Forest in Douglas County. Photo by Eric Epstein, Wisconsin DNR.

The Northern Wet Forest community complex encompasses the acid conifer swamps of black spruce and/or tamarack that grow on a more or less continuous substrate of sphagnum mosses. This community group is widespread in those areas where lakes and kettle depressions are characteristic topographic features (in areas of pitted glacial outwash). Inventory assessments targeting the acid conifer swamps have been limited to a relatively small number of the larger stands or to those occurring within vegetation ***mosaics*** that also contain other significant features such as Muskeg, Poor Fen, lakes and streams, and rare species. Most of the rare plants and animals associated with the forested acid peatlands have a strong range affinity for the boreal regions of Canada. Birds, vascular plants, butterflies, and a few additional invertebrates have received some attention here but at a relatively small number of sites.

Additional survey work is needed in the acid conifer swamps of this ecological landscape to identify those sites that contain large and/or intact stands, stands of especially high value to sensitive plants and animals, and sites that are critical in protecting water quality and attenuating flood flows.

The more extensive conifer swamps of this ecological landscape support many boreal birds, such as the Black-backed Woodpecker (*Picoides arcticus)*, Olive-sided Flycatcher (*Contopus cooperi*), Yellow-bellied Flycatcher (*Empidonax flaviventris*), Evening Grosbeak (*Coccothraustes vespertinus*), Gray Jay (*Perisoreus canadensis*), Cape May Warbler (*Setophaga tigrina*, listed as *Dendroica tigrina* on the Wisconsin Natural Heritage Working List), and many other northern wood warblers.

Savannas (Pine Barrens, Oak Barrens). The globally rare Pine Barrens community is better represented in the Northwest Sands than in any other ecological landscape in Wisconsin. Arguably, this is the most important place in North America to manage for this community. A combination of fire suppression, natural succession, and the conversion of land to other uses greatly reduced the amount of barrens habitat from what was present in the late 1800s to what exists today (Figure 17.6).

The federal public land survey notes indicated that almost two-thirds of this ecological landscape supported semi-open barrens vegetation in the mid-19th century. In the early 1900s, large areas of formerly open pine barrens were converted to agricultural uses or subsequently succeeded to dense dry forests due to the lack of fire. Clearing for farms and subsequent

Pine Barrens, with scattered jack pine interspersed with patches of heath (blueberries, Vaccinium *spp.; sweet fern,* Comptonia peregrina*) and prairie-like openings composed of native grasses, sedges, and forbs. Brule River State Forest, Douglas County. Photo by Eric Epstein, Wisconsin DNR.*

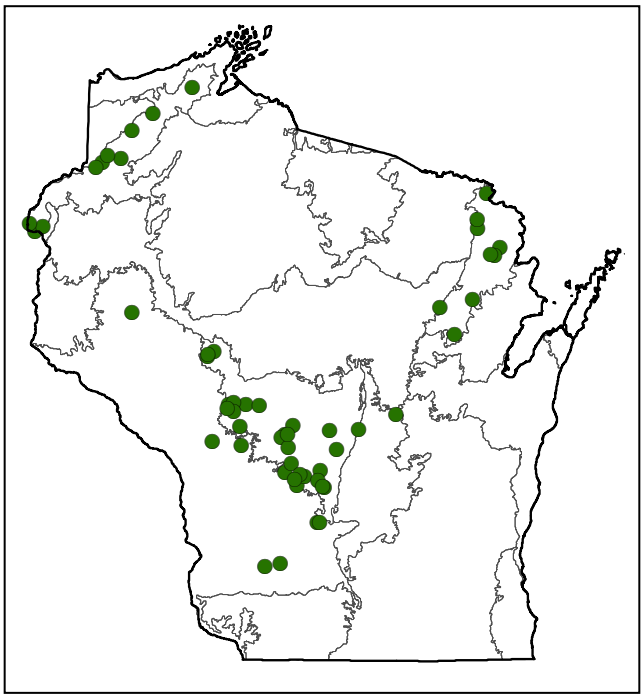


Figure 17.6. *Location of Pine Barrens in Wisconsin.*

succession to aspen, jack pine, and oak forests, and more recently to intensively managed pine plantations, has contributed to a loss of historical pine barrens structural and compositional characteristics, resulting in fragmented, simplified communities of lower structural and compositional diversity.

The increasing tree density in the nonagricultural areas of this ecological landscape has been accompanied by changes in vegetation patterns. Managed barrens now exist as static "islands" of mostly open land embedded within vast, densely stocked regional forests. Most of the pine and oak barrens remnants are too small and isolated to ensure long-term viability of all of their characteristic native plant and animal populations. An important management issue is how to connect these scattered openings, at least periodically, to reduce the negative impacts of population isolation. The extensive areas of public land may make it possible to connect existing critical protected areas by using semi-natural landscapes (e.g., a combination of managed forests and abandoned farms) as connecting corridors. Managing many thousands of acres in a mosaic of barrens, grasslands, wetlands, and dry forests may be the best way to protect some species, such as those that are area sensitive or need to reestablish themselves at different locations as the dynamic barrens habitats change. Providing for the periodic movement of barrens-dependent species between some of the now-isolated patches is a key long-term management consideration and could benefit many of the barrens associated birds, herptiles, butterflies, moths, plants, and others occurring in this ecological landscape.

Structure within the remnant barrens communities does not presently encompass the variability expressed by the barrens complex historically. Currently, woody plants, including deciduous saplings, are predominant in many areas, and grasses, forbs, "prairie shrubs," and their associated biota are reduced. At some locations, increasing the structural diversity and variability within the managed areas should be a conservation priority but not at the expense of the few, mostly open, managed areas that are barely large enough now to support populations of area-sensitive animals such as Sharp-tailed Grouse (*Tympanuchus phasianellus*). Managed open barrens often lack trees, or trees are represented by a dense growth of oak sprouts ("grubs"), hazelnut, and other woody brush 1 to 2 meters high. Such sites may have no pine component and are sometimes called "brush prairies." Stands with large, widely spaced red or jack pines, often referred to as pine "savannas" are now extremely localized and rare. Historically, they often occupied areas that were structurally transitional between closed forest and open, relatively treeless barrens. Early Euro-American settlers harvested almost all of the large red pines, thereby eliminating virtually all local seed sources.

The prairie component of the Pine Barrens community has a strong presence in the southwestern part of this ecological landscape, where some plants characteristic of Great Plains grasslands (some of these are rare and local in Wisconsin) may occur. The diversity of the native prairie flora gradually declines to the north and east. This is probably due to the influence of the major concentrations of lakes and wetlands, the much more rugged topography in the northern part of the ecological landscape, and wildfire behavior prior to Euro-American settlement. Other factors may include climatic tolerances of some of the individual prairie species as well as increasing distances from source populations.

This is an important rationale for protecting barrens throughout their historical range in the Northwest Sands—composition changes dramatically from southwest to northeast. It is also an excellent basis upon which to support the periodic connection of the persisting barrens patches.

Restoration efforts now include projects on county, state, and federal lands in Polk, Burnett, Douglas, and Bayfield counties. These sites are managed with prescribed fire and mechanical brushing to maintain the more open conditions required by many of the plants and animals dependent on or strongly associated with the barrens community. Fire is necessary for creating and maintaining suitable habitat for species such as Sharp-tailed Grouse and Kirtland's Warbler. While restoration of diminished wildlife habitat is the primary focus of these projects, some sites are also designed to function as firebreaks to protect property and large areas of fire-prone commercial forest. The areas managed as firebreaks are burned frequently to keep fuel loads low and to reduce the rapid spread of wildfires. These firebreaks have many benefits to the barrens-associated flora and to some fauna. They also enhance the effective size and connectivity of several of the managed barrens communities. Such areas are known locally as "fuelbreaks."

Though adapted to frequent natural disturbance, the Pine Barrens community is highly vulnerable to invasion by aggressive exotic plants such as leafy spurge (*Euphorbia esula*), spotted knapweed (*Centaurea biebersteinii*), and several cool-season grasses. The exposure of mineral soil that accompanies the development of fire breaks and access roads and the mechanical removal of woody vegetation creates conditions that are favorable for the establishment of these highly invasive weeds, which did not exist in this ecological landscape until recently. The role that grazing played, directly or indirectly, in the establishment of invasive plants here is unclear, but it may have been significant in those areas in which farming was attempted.

Historically, the most extensive Pine Barrens occurred in the Grantsburg Dunes (212Ka01), and Bayfield Level Barrens (212Ka06) Landtype Associations. Opportunities also exist in other Landtype Associations, and management emphasis there should assess the size range of barrens management projects, restoration potential of the suppressed or missing components, presence of rare or otherwise sensitive species, and the ability to conduct management activities that are compatible with other land uses in the vicinity.

Controlled burns are critical management tools used to restore and maintain the globally rare barrens communities and their many associated rare plants and animals. An additional benefit of such prescribed burns is the reduction in risk to human life and property by diminishing the fuel load. Photo by Robert Hanson, Wisconsin DNR.

Shrub Communities. The Alder Thicket community is widespread in northern Wisconsin, including the Northwest Sands Ecological Landscape. Alder Thicket may support rare plants, such as sheathed sedge (*Carex vaginata*), lesser wintergreen (*Pyrola minor*), and arrowhead sweet-colts-foot (*Petasites sagittatus*) and provides habitat for rare animals such as wood turtle (*Clemmys insculpta*) and Golden-winged Warbler (*Vermivora chrysoptera*) and for other animals of conservation concern such as Veery (*Catharus fuscescens*), American Woodcock (*Scolopax minor*), and snowshoe hare (*Lepus americanus*).

In the southern part of this ecological landscape, shrub swamps are sometimes dominated by dogwoods (*Cornus* spp.) and willows (*Salix* spp.). These are classified as Shrub-carr communities, but overall, shrub dominance by speckled alder, sometimes called tag alder (*Alnus incana*), is much more common.

Herbaceous Communities. Open wetlands, including bogs, fens, marshes, and sedge meadows, are common but localized communities of the Northwest Sands. The vast sedge meadows found in the southwestern part of this ecological landscape are particularly important because of their size, relatively undisturbed condition, and the many rare birds that are known to utilize them as nesting areas. These rare birds include Wilson's Phalarope (*Phalaropus bicolor*), Nelson's Sparrow (*Ammodramus nelsoni*), Le Conte's Sparrow (*Ammodramus leconteii*), American Bittern (*Botaurus lentiginosus*), Yellow Rail (*Coturnicops noveboracensis*), and Northern Harrier (*Circus cyaneus*). Many of the largest and least disturbed of these meadows occur on state-owned or state-managed lands and represent some of the most important opportunities statewide to protect and manage this community and its associated biota effectively.

Sedge meadows have frequently been converted to marshes with patches of open water by altering site hydrology through the construction of dikes. This is often for the purpose of creating additional habitat for waterfowl. The marshes created by such conversions have value to certain wildlife species, but care needs to be taken to avoid reducing the acreage of sedge meadow that sustains populations of many sensitive and rare animals and plants that do not find suitable habitat in marshes. Large, hydrologically intact sedge meadows are now scarce and becoming scarcer and should not be converted to widespread and common habitats such as emergent marshes without exceptional justification. The proximity of some of the largest meadows to barrens restoration and management projects has provided an additional benefit to area-sensitive

animals dependent on open landscapes as the effective size of the open areas has been greatly increased.

Marshes (Emergent Marsh, Wild Rice Marsh, Floating-leaved Marsh, and Submergent Marsh) are important components of the wetland vegetation mosaic in the Northwest Sands. Several marsh types may occur within a single wetland complex. Community boundaries are difficult to delineate because they may overlap spatially and shift in location from season to season or year to year as water levels fluctuate. Marshes may develop along sluggish stretches of major rivers, on the margins of lakes, or in shallow basins that receive nutrients from the surrounding watershed via overland flow, an inlet stream, or groundwater. Some of the larger marshes in the Northwest Sands occur along impounded portions of rivers or small streams, for example, at the Gordon Flowage on the St. Croix River or in some of the managed flowages at Crex Meadows. Wild Rice Marshes are well represented here compared to most other ecological landscapes and are important ecological, cultural, and socioeconomic features. Cranberry operations, though currently of limited extent here, have the potential to decrease the amount of wetland habitat, alter wetland communities, and affect local hydrology and water quality.

Many species of waterbirds, shorebirds, raptors, mammals, herptiles, and invertebrates use marshes and sites that support dense beds of emergent, floating-leaved, and submergent aquatic vegetation. These sites provide critical habitat for rare or uncommon birds such as Red-necked Grebe (*Podiceps grisegena*), Trumpeter Swan (*Cygnus buccinator*), Redhead (*Aythya americana*), Ring-necked Duck (*Aythya collaris*), American Bittern, Least Bittern (*Ixobrychus exilis),* Black Tern (*Chlidonias niger*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). These species and many others rely heavily on marshes for breeding, foraging, and migration stop-over sites.

Miscellaneous Natural Communities. Inland Beach communities occupy the littoral zones of lakes and, more rarely, streams. They are most often associated with seepage lakes found on pitted outwash landforms characterized by sand or gravel substrates. Fluctuations in the amount of precipitation, overland flow, and groundwater input produce cycles of inundation and recession. High water sets back succession from dominance by rank graminoids, forbs, and shrubs, while low water periods create habitat conditions favorable for the growth of the sometimes highly specialized plants and animals associated with beaches. No one has conducted a comprehensive inventory of either the Inland Beach community or its biota. The potential for making significant floristic discoveries is high, especially for highly specialized beach plants, given the large number of lakes in this ecological landscape.

Floristic rarities known to occur in the littoral zones of northwestern Wisconsin seepage lakes and ponds include rugulose grape fern (*Botrychium rugulosum*), slender bulrush (*Schoenoplectus heterochaetus*), Torrey's bulrush (*S. torreyi*) and northeastern bladderwort (*Utricularia resupinata*). Past inventory work on shoreline vegetation has been spotty, primarily focusing on sites in the Chequamegon-Nicolet National Forest, in the southern part of the Brule River State Forest, and at a few other scattered locations. Commercial and private housing developments are increasing and encroaching on lakeshores. More comprehensive survey work is needed to evaluate the potential impact upon shoreline habitats posed by increased residential development. See "Inland Lakes: Seepage Lakes, Drainage Lakes" in "Management Opportunities for Important Ecological Features of the Northwest Sands" below for the distribution of major lake concentrations by Landtype Association.

Aquatic Communities. The Northwest Sands harbors several significant concentrations of soft-water seepage lakes that provide habitat for numerous organisms that depend at least partially on high quality aquatic habitats and undeveloped shorelines. Shallow lakes of this type are common here and are often associated with beds of submergent, floating-leaved, and emergent aquatic vegetation. Residential development pressure on seepage lakes is high throughout the state, and the Northwest Sands is no exception. Proximity to the Twin Cities exacerbates this situation. As larger lakes become more fully developed, small lakes now face more intensive development. Many lakes are likely to experience the impacts of both local and watershed-level land use changes (less forest, loss of shoreline vegetation, more roads, more impervious surface, increased use of herbicides, etc.) that often accompany increased residential development.

The St. Croix, Namekagon, Totagatic, Bois Brule, and Eau Claire rivers warrant special conservation attention because of their generally excellent water quality and the exceptional aquatic biota that is dependent on them. In some cases, for example, along the St. Croix and Bois Brule rivers, the vegetated river corridors are also highly significant because they support extensive, high quality natural communities and rare species. There are numerous dams on streams, affecting river habitats by altering natural flood regimes, increasing water temperature, and fragmenting aquatic systems by creating barriers that impede species movement. Maintaining these river corridors in an intact, unfragmented condition is a primary conservation consideration. Commercial and private housing developments are increasing and encroaching on riparian areas. Manipulated waterbodies with exposed muddy shorelines are vulnerable to colonization by invasive plants if not managed carefully. Care should be taken not to introduce these species.

Forest Habitat Types

Forest habitat types as described by Kotar and others (1988, 2002) were developed to aid planners, foresters, restoration ecologists, and others in determining site potential for forest management. Forest habitat types are identified by the presence of diagnostic ground flora and shrubs. Habitat type descriptions are associated with information on the various

tree species that can grow on a site and include descriptions of successional pathways in the absence of disturbance. A summary of forest habitat types is found in Appendix 17.B.

Forest habitat type groups are groups of habitat types based on similarities in their moisture and nutrient requirements. The northern very dry to dry habitat type group (see Table 17.2) is dominant in forests of the Northwest Sands. The northern very dry to dry habitat types are the driest, most nutrient-poor sites in northern Wisconsin and potentially support jack pine, red pine, or oak. The oaks are valuable for wildlife and for other reasons but are typically slow-growing and have a brushy, thicket-like form that makes them undesirable for timber. This habitat type group includes types that historically occurred on the Northwest Sands as pine barrens under a disturbance regime of periodic wildfire.

The habitat type groups that are common include the northern dry to dry-mesic group and the northern wet-mesic to wet group. The northern dry to dry-mesic habitat types are found on sites with slightly higher levels of moisture and nutrients that can support eastern white pine, red pine, red maple, aspen, and oaks. The northern wet-mesic to wet habitat types are found on hydromesic sites and generally support tamarack and black spruce.

Flora

This section highlights rare plant species that are or may be significant in the Northwest Sands for one or more of the following reasons:

- A relatively high percentage of Wisconsin populations occur here.
- Populations are among the largest known anywhere within Wisconsin.
- There are good opportunities for effective population protection and habitat maintenance.
- There is a high probability of discovering new populations.
- They are rare in Wisconsin, regionally, or continentally.

Forty-six vascular plant species inhabiting the Northwest Sands are included on the Wisconsin Natural Heritage Working List since 1970 (WDNR 2009b). Of these 46 species, four are listed as Wisconsin Endangered, nine as Wisconsin Threatened, and 33 as Wisconsin Special Concern. No federally listed plants have been documented here. However, at least one of the rare plants found in the Northwest Sands, the Wisconsin Threatened bog bluegrass (*Poa paludigena*), is considered globally rare.

Both Wisconsin records for the Wisconsin Endangered Lapland buttercup (*Ranunculus lapponicus*) are from the Northwest Sands. The following vascular plants have 25–50% of their state populations within the Northwest Sands: rugulose grape fern, autumnal water-starwort (*Callitriche hermaphroditica*), Richardson sedge (*Carex richardsonii*), sheathed sedge, silky prairie-clover (*Dalea villosa* var. *villosa*), crinkled hairgrass (*Deschampsia flexuosa*), marsh willow-herb (*Epilobium palustre*), large-flowered ground-cherry (*Leucophysalis grandiflora*), large round-leaved orchid (*Platanthera orbiculata*), and lesser wintergreen. From this group, lesser wintergreen is Wisconsin Endangered; the others are Wisconsin Special Concern (WDNR 2009b).

Table 17.2. *Forest habitat type groups and forest habitat types[a] of the Northwest Sands Ecological Landscape (NWS EL).*

Forest habitat type groups[b]	Forest habitat types common within the NWS EL	Forest habitat types minor within the NWS EL
Dominant within within the NWS EL		
Northern very dry to dry (VD-D)	PQG PQGCe PArV-U	QAp
Common within the NWS EL		
Northern dry to dry-mesic (D-DM)	PArVAm	ParVAa-Po
Northern wet-mesic to wet (WM-W)	HM hydromesic site	
Minor within the NWS EL		
Northern dry-mesic (DM)	AVDe	AVCl ACl
Northern mesic to wet-mesic (M-WM)	ArVRp ArAbVCo	ASnMi

Source: Kotar et al. (2002).

[a]Forest habitat types are explained in Appendix 17.B ("Forest Habitat Types in the Northwest Sands Ecological Landscape") at the end of this chapter.

[b]Groups listed in order from most to least common:
Dominant occurrence is an estimated > 50% of forested land area.
Common occurrence is an estimated 10–50% of forested land area.
Minor occurrence is an estimated 1–9% of forested land area.
Present: Other habitat types can occur locally, but each represents < 1% of the forested land area of the ecological landscape.

The Lapland buttercup is known in Wisconsin only from a handful of conifer swamps in the Northwest Sands. Photo by J. Grahn.

The fairy slipper (Wisconsin Threatened) is a rare orchid that grows in rich conifer swamps. Photo by Thomas Meyer, Wisconsin DNR.

Species that are not quite as well represented here based on the number of documented populations (less than 25% of the known populations occur in the Northwest Sands) but for which there are nevertheless significant management opportunities are dwarf milkweed (*Asclepias ovalifolia*), fairy-slipper orchid (*Calypso bulbosa*), Michaux's sedge (*Carex michauxiana*), and small yellow lady's-slipper (*Cypripedium parviflorum* var. *makasin*). The milkweed, fairy slipper, and Michaux's sedge are listed as Wisconsin Threatened; the lady's slipper is listed as Wisconsin Special Concern (WDNR 2009b).

Many of the rare plant species with significant representation here are associated with specific natural communities or landscape complexes. Examples of communities that are especially important to rare plants in the Northwest Sands include Northern Wet-mesic Forest (northern white-cedar swamp), Pine and Oak Barrens, open peatlands (such as Poor Fen and Muskeg), and Alder Thicket. Managing for the perpetuation of these communities at appropriate scales and contexts will help ensure the survival of these species. Other communities or habitats that support rare plants are beaches, spring seeps, seepage lakes and ponds, xeric forests, marshes, and river banks.

Pine and Oak Barrens were formerly abundant in the Northwest Sands. Though remnants are greatly reduced in extent and often degraded, important barrens restoration and management projects are in progress at several sites here. Rare plants associated with barrens habitats include dwarf milkweed, silky prairie-clover, Richardson sedge, crinkled hairgrass, and dotted blazing-star (*Liatris punctata* var. *nebraskana*). Barrens remnants are also regional repositories for much of our native prairie flora—including species that have been deemed common but that now occupy far less

Significant Flora in the Northwest Sands Ecological Landscape

- Many rare or otherwise sensitive plants in the Northwest Sands are associated with fire-adapted ecosystems such as barrens and dry pine or oak forests.
- Some members of the barrens flora may require periodic wildfire for their long-term maintenance.
- Inland beach communities occur on the margins of sand-bottomed seepage lakes, providing habitat for specialized plants and animals.
- Aquatic plants are well represented in the lakes, ponds, streams, and wetlands of the Northwest Sands.
- Wild rice marshes occur in shallow drainage lakes in the Northwest Sands.
- The spring-fed northern white-cedar swamps along the upper Brule River support an exceptionally diverse flora.

Dwarf milkweed (Wisconsin Threatened) reaches its Wisconsin range limits in the barrens of the Northwest Sands Ecological Landscape. Photo by Eric Epstein, Wisconsin DNR.

habitat than they did historically. Barrens remnants in this ecological landscape also include several plant species that are more characteristic of the grasslands in the Great Plains, such as the Wisconsin Endangered dotted blazing star and the blue giant hyssop (*Agastache foeniculum*).

Northern Wet-mesic Forests (northern white-cedar swamps) are fed by and dependent on groundwater seepage. The distinctive and diverse assemblage of plants such habitats support includes fairy-slipper orchid, sheathed sedge, small yellow lady's-slipper, Lapland buttercup and northern black currant (*Ribes hudsonianum*). Regeneration of the dominant tree, northern white-cedar, is now negligible here, which is also the case throughout most of Wisconsin. Excessive herbivory by white-tailed deer (*Odocoileus virginianus*) and, to a much lesser degree, snowshoe hare, are among the important causes of northern white-cedar's reproductive failure.

Alder Thickets support a surprisingly large number of rare species, especially when one considers the small area occupied by alder and the lack of attention this community has received from botanists and other biologists. Among the rare plants documented in alder-dominated habitats of the Northwest Sands are bog bluegrass, sheathed sedge, lesser wintergreen, and arrowhead sweet-colts-foot.

Older forests of pine and oak (especially Northern Dry-mesic Forest, in which the dominants are eastern white pine, red pine, and northern red oak) provide habitat for species such as Hooker's orchid (*Platanthera hookeri*) and large round-leaved orchid, both Wisconsin Special Concern species in 2009 (WDNR 2009b).

Seepage lakes that naturally experience periodic water level fluctuations are common in portions of the Northwest Sands. When water levels drop, bare sand or gravel may be exposed in a zone along the shore, creating unoccupied habitat that is ideal for a group of plant specialists that are adapted to rapidly colonizing and quickly dominating such environments. Over time the open beaches are taken over by coarse herbs and shrubs, and populations of the beach specialists (often including grasses, rushes, and sedges, among others) decline. When water levels rise, the rank species are inundated and suppressed. As the water levels drop, bare substrates once again become available for the beach specialists.

Because lakes are common and shoreline surveys targeting rare species have not been comprehensive here, the chances of discovering new populations of rare plants and invertebrates would seem to be high. For example, just to the east of the Northwest Sands, on the shores of seepage lakes with characteristics similar to those found in parts of the Northwest Sands (Pigeon Lake, near Drummond in Bayfield County is a good example) grow some of Wisconsin's rarest plants: Fassett's locoweed (*Oxytropis campestris* var. *chartacea*) and alpine milk-vetch (*Astragalus alpinus*). Habitats that are apparently equivalent, or at least very similar, also appear to be associated with other seepage lakes within the Northwest Sands. A point of emphasis for managers and conservation planners is that such lakes must be allowed to fluctuate within their natural range of variation. To stabilize water levels could result in the permanent loss of the dynamic beach habitats and the specialized organisms they support. Rare plants that have been documented on the strands or in the shallows of the seepage lakes in the Northwest Sands include slender bulrush, Torrey's bulrush, and rugulose grape fern.

Rugulose grape fern is a globally rare fern that is known from two locations in the Northwest Sands. Photo by N.L. Taylor.

Fassett's locoweed (U.S. Threatened; Wisconsin Endangered) is a globally rare plant known only from the shores of a few lakes in the sandy regions of central and northwestern Wisconsin. Photo by Thomas Meyer, Wisconsin DNR.

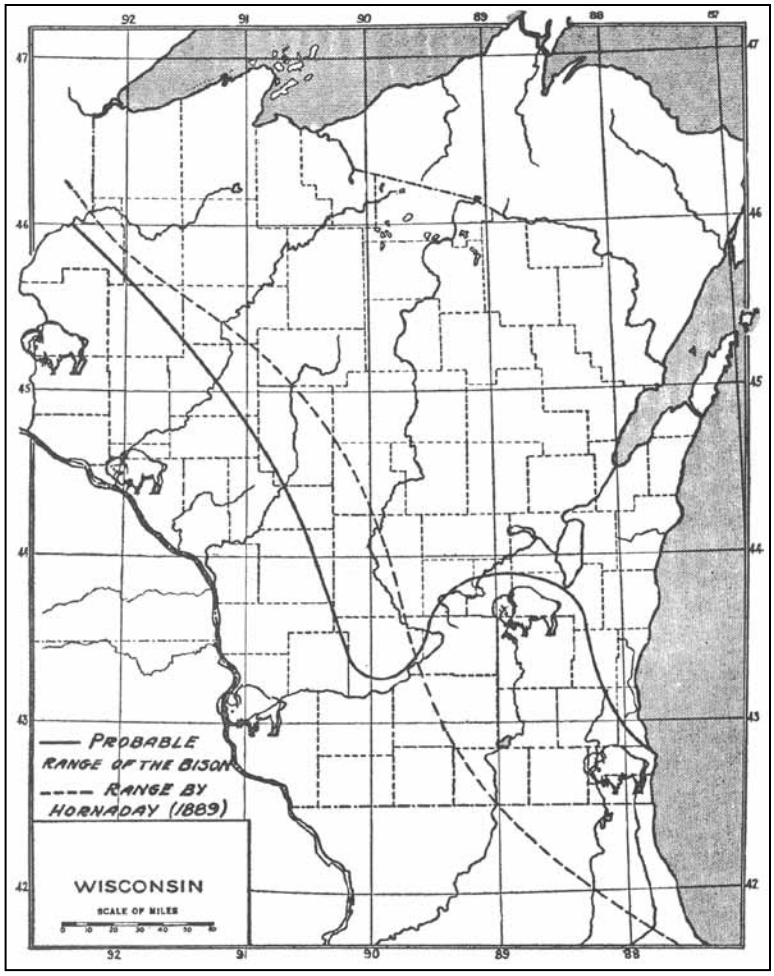


Figure 17.7. *Probable range of the American bison in Wisconsin prior to Euro-American settlement. Figure reproduced from Schorger (1937) by permission of the Wisconsin Academy of Sciences, Arts and Letters.*

Additional information on the flora of the Northwest Sands Ecological Landscape may be found elsewhere in this chapter, especially in the "Vegetation and Land Cover" and "Natural Communities" sections.

Fauna

Changes in Wildlife over Time

Many wildlife populations have changed dramatically since humans arrived on the landscape, but these changes were not well documented before the mid-1800s. This section discusses only those wildlife species documented as having occurred in the Northwest Sands. Of those, this review is limited to species that were known to be or thought to be especially important here in comparison to other ecological landscapes in Wisconsin. For a more complete review of historical wildlife in the state, see Chapter 4, "Changes and Trends in Ecosystems and Landscape Features," and a collection of articles written by A.W. Schorger, compiled into the volume *Wildlife in Early Wisconsin: A Collection of Works by A.W. Schorger* (Brockman and Dow 1982).

The Northwest Sands Ecological Landscape was important historically for many wildlife species, especially grassland, barrens, and wetland wildlife. The Northwest Sands was particularly important for elk (*Cervus canadensis*), American bison (*Bos bison*), moose (*Alces americanus*), gray wolf (*Canis lupus*), American beaver (*Castor canandensis*), North American river otter (*Lontra canadensis*), Trumpeter Swan, and Sharp-tailed Grouse. Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), and Common Loon (*Gavia immer*) were also important in this ecological landscape (see Chapter 14, "Northern Highland Ecological Landscape," for a more detailed historical description of these three bird species), as were many species of grassland and barrens associated wildlife. With the arrival of Euro-American settlers, fires were suppressed, and the sand prairies and pine barrens grew up into jack pine and oak forests. Some areas were converted to farms. With these major habitat changes, wildlife populations also changed.

American bison may have occurred in this ecological landscape, but bison appeared to be at the northern edge of its range here (Figure 17.7).

Based on the presence of prairie vegetation in this ecological landscape and sketchy descriptions by Radisson (Schorger 1937), bison likely occurred in the southwestern part of the Northwest Sands. Bison are believed to have been extirpated from the state by 1800 (see the "Fauna" section of Chapter 20, "Southwest Savanna Ecological Landscape," for a more complete description of bison in the state). No free-ranging bison occur in the Northwest Sands today.

Moose were located throughout the forested regions of Wisconsin prior to Euro-American settlement (Schorger 1956) and were considered fairly common in the state. The largest populations of moose occurred in the northwestern part of the state (Figure 17.8; Schorger 1956), so they also occurred in the Northwest Sands Ecological Landscape, especially where shallow lakes and shrubby wetlands provided good foraging areas. Moose are believed to have been extirpated from the state by 1900. Today moose occasionally wander into Wisconsin from northern Michigan or Minnesota, and some have been reported in or very close to this ecological landscape.

Although woodland caribou (*Rangifer tarandus*) occurred in Wisconsin historically, they were never abundant because the amount of mature, unfragmented boreal forest, the preferred habitat for caribou, is very limited here. Bones of caribou have been found as far south as Polk county (Schorger 1942), and there are some records from northwestern Wisconsin (Jackson 1961), but it is unlikely that they were ever abundant in the Northwest Sands. Today there are no caribou in the Northwest Sands, nor anywhere else in the state.

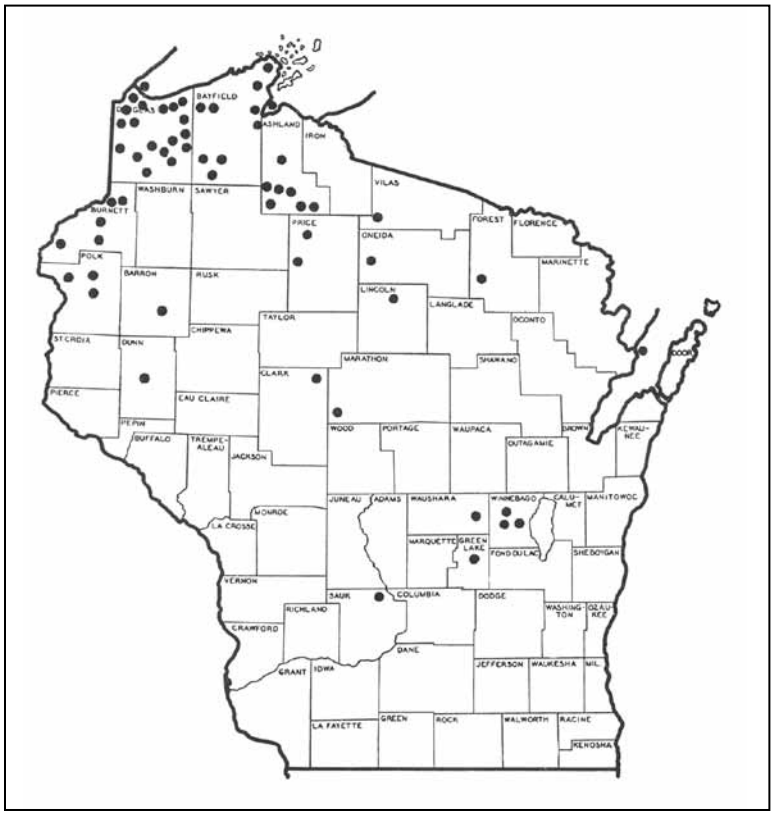


Figure 17.8. *Historical records of moose in Wisconsin prior to Euro-American settlement. Figure reproduced from Schorger (1956) by permission of the Wisconsin Academy of Sciences, Arts and Letters.*

White-tailed deer were found throughout the state but were more abundant in southern Wisconsin than in the north (Schorger 1953) at the time of Euro-American settlement. Northern Wisconsin was primarily mature coniferous-deciduous forest, not optimal habitat, which limited the white-tailed deer population there. However, the extensive pine barrens vegetation in the Northwest Sands may have provided habitat to sustain more white-tailed deer than in most other places in northern Wisconsin. The large number of settlers that followed logging in northern Wisconsin depended on venison for food. Subsistence harvest, together with market hunting, likely reduced the state's white-tailed deer population to its lowest level around 1900.

The white-tailed deer population expanded and increased again in the middle of the last century, and especially since the 1980s (Figure 17.9; for more detailed discussion of the recovery of white-tailed deer population, see the "Fauna" section in Chapter 12, "North Central Forest Ecological Landscape"). Today white-tailed deer populations in this ecological landscape are large compared to what they were prior to Euro-American settlement. Logging and other human activities have provided abundant food for white-tailed deer. Relatively mild winters during the decades of the 1990s and 2000s prevented winter starvation and allowed the white-tailed deer herd to increase. Winter feeding of white-tailed deer by well-intentioned people has been popular since the 1990s and may be contributing to increased winter survival and increased production of offspring the following spring. The current white-tailed deer management program sets white-tailed deer population goals for units within the state and has used antlerless white-tailed deer harvest to keep the white-tailed deer population at the established goal. The white-tailed deer herd has often been above the goal for the Northern Forest (Figure 17.10) and overbrowsing of more palatable plants is also becoming more common in the Northwest Sands.

The gray wolf was found throughout the wooded regions of Wisconsin and was common in the prairie regions as well (Schorger 1942). After Euro-American settlement, the gray wolf population declined dramatically, especially in southern Wisconsin, due to a reduction in food resources (white-tailed deer and rabbits), indiscriminate shooting, and bounties. By the 1930s, the gray wolf was confined to the northernmost part of Wisconsin and by the early 1970s may have been extirpated. Historically the gray wolf

occurred in the Northwest Sands, as it was present throughout most of the state. The Northwest Sands played an important role in the recolonization of Wisconsin by gray wolves from Minnesota, since it is located along the major dispersal corridor between the two states. Today, wolves are resident in this ecological landscape. There were over 800 wolves in Wisconsin in 2012 (Wydeven et al. 2012).

The American beaver was once abundant throughout the state where suitable streams, lakes, and forests existed (Schorger 1965). Due to indiscriminate trapping and hunting for furs, both the American beaver and the fur trade declined in Wisconsin by the early 1800s. The American beaver was thought to be near extirpation from Wisconsin by the 1880s. The American beaver was likely abundant in the Northwest Sands historically, but here too it declined dramatically under heavy trapping and hunting pressure. Today the American beaver has become abundant again both statewide and in the Northwest Sands, to the point where they cause problems and user conflicts by flooding roads with their dams and reducing suitability of coldwater streams for trout by causing water temperatures to rise behind their dams.

Sharp-tailed Grouse use grassy and brushy habitats. Prior to Euro-American settlement, they were found in the regions of the state that burned frequently, especially in prairie-savanna areas (Schorger 1943). Sharp-tailed Grouse may have been more abundant in the Northwest Sands Ecological Landscape than elsewhere due to the availability of extensive open, brushy habitats. Following the Cutover period, Sharp-tailed Grouse became more abundant throughout northern Wisconsin. After Euro-American settlement, the range of the Sharp-tailed Grouse contracted due to the reduction in wildfire, maturation of the regenerated forests, and a general increase in woody cover. Today, the Northwest Sands Ecological Landscape is the last stronghold of the Sharp-tailed Grouse in Wisconsin, though small, scattered, isolated populations occur at a few other locations.

The Trumpeter Swan nested in Minnesota and Wisconsin until the 1880s. In Minnesota, the species occurred in the prairie and prairie-parkland areas of the western, central, and northern portions of the state. In Wisconsin, Trumpeter Swans may have nested in all but the northeastern forested regions. They most likely nested in large marshes or shallow lakes in the Northwest Sands. By 1900 the Trumpeter Swan

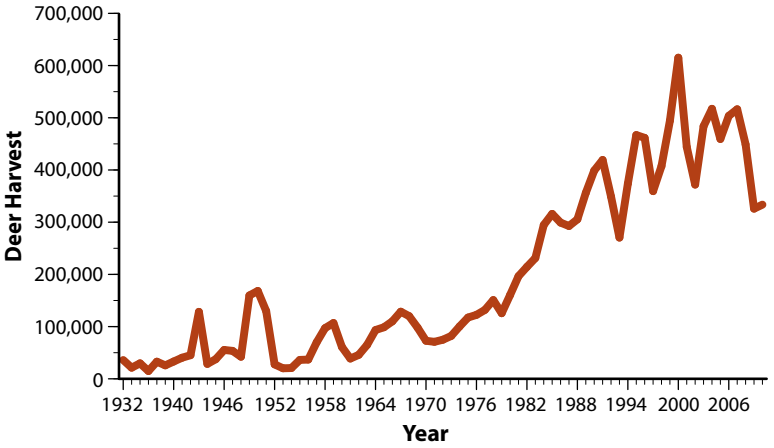


Figure 17.9. *Statewide white-trailed deer harvest, 1932–2010 (Wisconsin DNR unpublished data).*

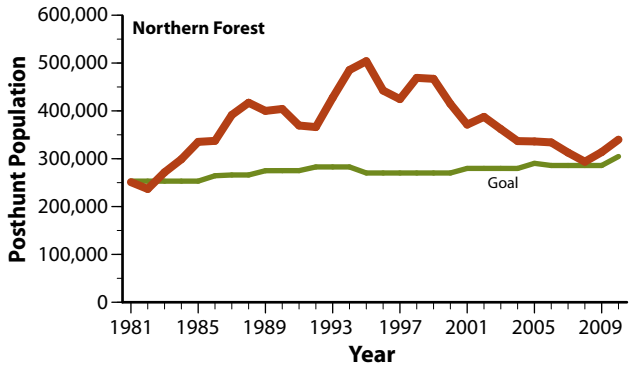


Figure 17.10. *White-tailed deer population size in relation to population goals in the northern forest deer management region, 1981–2010 (Wisconsin DNR unpublished data).*

was thought to be extinct. Fortunately, a small nonmigratory population survived in the remote mountain valleys of Montana, Idaho, Wyoming, and Alaska. Since then there has been a concerted effort to restore the species and reestablish populations across parts of its historical breeding range that still had suitable nesting habitat.

Within the Northwest Sands Ecological Landscape, the Trumpeter Swan was recently reintroduced at Crex Meadows State Wildlife Area (and in several other parts of the state). Breeding pairs have occupied Crex Meadows and other nearby sites, and a self-sustaining population has now been established in the region. (See the "Fauna" section of Chapter 10, "Central Sand Plains Ecological Landscape," for a more detailed discussion of this species.)

Significant Fauna

Wildlife are considered significant for an ecological landscape if (1) the ecological landscape is considered important for maintaining the species in the state and/or (2) the species provides important recreational, social, and economic benefits to the state. To ensure that all species are maintained in Wisconsin, "significant wildlife" includes both common species and species that are considered "rare" (in this publication "rare" includes species listed as endangered or threatened by either Wisconsin or the federal government or species that are listed as special concern by the State of Wisconsin).

Four categories of species are discussed: rare species, Species of Greatest Conservation Need (SGCN), responsibility species, and socially important species (see definitions in text box). Note that there is some overlap among the four categories. Because maintaining natural communities and other important habitats is the most efficient way to manage and benefit a majority of species, we also discuss management of different habitats in which significant fauna occur.

Rare Species. "Rare" animals include all of those species that appear on the Wisconsin Natural Heritage Working List (WDNR 2009b) and are classified as endangered, threatened, or special concern by the State of Wisconsin or the federal government. (See Appendix 17.C for a comprehensive list of the rare animals known to exist in the Northwest Sands.) As of November 2009, the Wisconsin Natural Heritage Working List documented 89 rare species including 4 mammals, 28 birds, 7 herptiles, 6 fishes, and 44 invertebrates within the Northwest Sands Ecological Landscape. These include 2 U.S. Endangered species (these also have state status), 4 Wisconsin Endangered species, 11 Wisconsin Threatened species, and 74 Wisconsin Special Concern species. See Appendix 17.D for the number of species per taxa with special designations documented within the Northwest Sands.

Federally Listed Species. Two federally listed animals occur in this ecological landscape. The Karner blue butterfly (*Lycaeides melissa samuelis*) is listed as U.S. Endangered and occurs in the southern part of the ecological landscape. It is managed under a Habitat Conservation Plan approved by the U.S. Fish and Wildlife Service. It is listed as a Wisconsin Special Concern species (WDNR 2009b). The U.S. Endangered Kirtland's Warbler has been found in the ecological landscape (only males) in past decades. It is listed as a Wisconsin Endangered species in 2015. The gray wolf, which occurs in this ecological landscape, was removed from the federal threatened species list in January 2012, granting management authority to the State of Wisconsin. The Wisconsin state legislature passed a law in April 2012 authorizing hunting and trapping seasons for wolves and directed that gray wolf hunting and trapping seasons be held starting in the fall of 2012. The first hunting and trapping seasons of wolves were therefore conducted during October–December 2012. Wolves are now being managed under a 1999 gray wolf management plan (WDNR 1999b) with addenda in 2006 and 2007, but the plan is being updated to reflect these recent changes in gray wolf management in Wisconsin. The Bald Eagle (formerly U.S. Threatened) is also found here. Since its delisting in 2007, the Bald Eagle remains protected under the federal Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The Bald Eagle is listed as a Wisconsin Special Concern species.

Wisconsin Endangered Species: No Wisconsin Endangered mammals occur in this ecological landscape (WNDR 2009b). One Wisconsin Endangered bird, Red-necked Grebe; no herptiles;

Categories of Significant Wildlife

- **Rare species** are those that appear on the Wisconsin Natural Heritage Working List as Wisconsin or U.S. Endangered, Threatened, or Special Concern.
- **Species of Greatest Conservation Need** are described and listed in the Wisconsin Wildlife Action Plan (WDNR 2005c) as those native wildlife species that have low or declining populations, are "indicative of the diversity and health of wildlife" of the state, and need proactive attention in order to avoid additional formal protection.
- **Responsibility species** are both common and rare species whose populations are dependent on Wisconsin for their continued existence (e.g., a relatively high percentage of the global population occurs in Wisconsin). For such a species to be included in a particular ecological landscape, a relatively high percentage of the state population needs to occur there, or good opportunities for effective population protection and habitat management for that species occur in the ecological landscape. Also included here are species for which an ecological landscape holds the state's largest populations, which may be critical for that species' continued existence in Wisconsin even though Wisconsin may not be important for its global survival.
- **Socially important species** are those that provide important recreational, social, or economic benefits to the state for activities such as fishing, hunting, trapping, and wildlife watching.

The Karner blue butterfly (U.S. Endangered, Wisconsin Special Concern) reaches its northwestern range limits in the barrens of northwestern Wisconsin, especially in Burnett County. The thumb of Wisconsin DNR biologist Gregor Schuurman was an attractive perch for this Karner blue. Photo by Gregor Schuurman, Wisconsin DNR.

no fish; one mussel, purple wartyback (*Cyclonaias tuberculata*); and two other invertebrates, extra-striped snaketail (*Ophiogomphus anomalus*) and phlox moth (*Schinia indiana*) are found here.

■ ***Wisconsin Threatened Species:*** There are no Wisconsin Threatened mammals here. The Wisconsin Natural Heritage Working List (WDNR 2009b) documents five Wisconsin Threatened birds: Red-shouldered Hawk (*Buteo lineatus*), Yellow Rail, Spruce Grouse (*Falcipennis canadensis*), Greater Prairie-Chicken (*Tympanuchus cupido*), and Hooded Warbler (*Setophaga citrina,* listed as *Wilsonia citrina* on the Working List); two Wisconsin Threatened herptiles: wood turtle and Blanding's turtle (*Emydoidea blandingii*), and three Wisconsin Threatened fishes: greater redhorse (*Moxostoma valenciennesi*), pugnose shiner (*Notropis anogenus*), and gilt darter (*Percina evides*). However, recent surveys have documented another Wisconsin Threatened fish here, the river redhorse (*Moxostoma carinatum*). It was found at six or more locations on the lower Namekagon and St. Croix rivers in 2009. These records had not yet been added to the Natural Heritage Inventory database at the time of this writing in 2009; they are not reflected in the number of Wisconsin Threatened fishes in this ecological landscape. One Wisconsin Threatened invertebrate, the pygmy Snaketail (*Ophiogomphus howei*), has been documented within the Northwest Sands.

■ ***Wisconsin Special Concern Species:*** Wisconsin Special Concern species found here include 4 mammals, 22 birds, 5 herptiles, 3 fishes, and 40 invertebrates (WDNR 2009b; see Appendix 17.C for a complete list of Wisconsin Special Concern species).

■ **Species of Greatest Conservation Need.** Species of Greatest Conservation Need (SGCN) appear in the Wisconsin Wildlife Action Plan (WDNR 2005c) and include species already recognized as endangered, threatened, or special concern on Wisconsin or federal lists and also include more common (unlisted) species that are declining. There are 5 mammals, 45 birds, 9 herptiles, and 7 fish species listed as SGCN for the Northwest Sands Ecological Landscape (see Appendix 17.E for a complete list of Species of Greatest Conservation Need and the habitats with which they are associated).

■ **Responsibility Species.** The Northwest Sands has the best opportunity to manage for Sharp-tailed Grouse in the state. There are only two other ecological landscapes that have Sharp-tailed Grouse populations, the Central Sand Plains and North Central Forest (Fandel and Hull 2011). The populations in these two ecological landscapes are small and isolated. The Sharp-tailed Grouse population in the Northwest Sands is the largest in the state and has the best opportunity to be sustainable. Habitat is managed for Sharp-tailed Grouse within the Northwest Sands at Crex Meadows, Fish Lake, Namekagon Barrens, and Douglas County Wildlife Areas and at Moquah Barrens in the Chequamegon-Nicolet National Forest. Management should focus on connecting the larger core population areas by cooperative management of local, county, state, federal, and NGO lands. Although the Sharp-tailed Grouse population is somewhat cyclical in Wisconsin, it is showing a long-term decline (Gregg and Niemuth 2000). The Sharp-tailed Grouse range has been contracting in Wisconsin, and the remaining Sharp-tailed Grouse populations in Wisconsin are becoming more isolated. There is concern that the populations are becoming genetically isolated, losing genetic variability, and may lose vigor. Preliminary DNA analysis suggests that there is some genetic interchange among local populations, but it may not be enough to sustain the state population of Sharp-tailed Grouse in the state (Fandel and Hull 2011). Translocation of birds from within the state as well as from other states may be necessary to maintain or increase the genetic diversity of current populations (Kreitinger et al. 2013). Hunting of Sharp-tailed Grouse in Wisconsin is allowed under a strict quota and permit system. The harvest of Sharp-tailed Grouse is very low (<5% of the total population) and is not likely contributing to the overall population decline (Gregg 1987, Niemuth 2006). For a more detailed discussion on Sharp-tailed Grouse management in Wisconsin, see Fandel and Hull (2011).

The Trumpeter Swan was reintroduced at Crex Meadows and Fish Lake State Wildlife Areas within the Northwest Sands in 1989 (as well as in the Central Sand Plains and Southeast Glacial Plains ecological landscapes). Breeding pairs have occupied Crex Meadows since then and have established a self-sustaining population there. The population has continued to increase and expand to other wetland sites in the region.

Reports of male Kirtland's Warblers in this ecological landscape occurred in the late 1980s and early 1990s. Since the Kirtland's Warbler requires 2–5 meter-high jack pine for nesting, the Northwest Sands has potential to provide habitat for additional breeding populations. To date, no nesting of the Kirtland's Warbler has been confirmed in this ecological landscape although nesting has been documented in the

A pair of Trumpeter Swans and cygnet at Fish Lake, Burnett County. Photo by Brian Collins.

Central Sand Plains and, to a more limited extent, in the Northeast Sands.

The Wisconsin Threatened Yellow Rail is an uncommon bird that inhabits sedge meadows. Crex Meadows State Wildlife Area is one the few places in the state where it has been found consistently (Cutright et al. 2006). Maintaining extensive sedge meadows of the appropriate composition and structure will continue to provide suitable nesting habitat for this secretive species.

The Karner blue butterfly, a U.S. Endangered species, reaches its northern range limits in the southern part of the Northwest Sands where its larval host plant, wild lupine (*Lupinus perennis*), grows in pine and oak barrens habitats. Since Wisconsin has the largest remaining population of this species in the world, the continued existence of the Karner blue here is important. A common feature of good quality Karner blue habitat includes a range of canopy cover from nearly full sun to semi-closed canopy with patchy openings, conditions that allow full or filtered sunlight to reach the low-growing lupine plants. Lupine grows best in sandy soils and in full or filtered sun where competition from shrubs and tall grasses is minimal. Wild lupine may spread quickly in areas recently cleared by fire, logging, grazing, or other disturbance. The Karner blue is managed under the guidance provided by a Habitat Conservation Plan approved by the U.S. Fish and Wildlife Service (WDNR 2010b). The phlox moth, listed on the Wisconsin Natural Heritage Working List as Wisconsin Endangered, also occurs in barrens habitat in the southern part of the ecological landscape. It often co-occurs with the Karner blue because it requires similar habitat conditions. Its larval host plant is downy phlox (*Phlox pilosa*).

Many populations of rare invertebrates, including dragonflies, mussels, and aquatic beetles, have been documented in larger rivers such as the St. Croix, Namekagon, and Bois Brule. One globally rare dragonfly species, the St. Croix snaketail (*Ophiogomphus susbehcha*), is known from streams within the Northwest Sands. The purple wartyback mussel, a Wisconsin Endangered species, is also found in these rivers, as are rare fishes and other aquatic invertebrates. This ecological landscape is especially important for the Wisconsin Threatened gilt darter because its favored habitat of deep pools, with clean, silt-free bottoms of gravel, rubble and boulders, occurs in some streams here.

Socially Important Fauna. Species such as white-tailed deer, American black bear (*Ursus americanus*), American beaver, North American river otter, fisher (*Martes pennanti*), Ruffed Grouse (*Bonasa umbellus*), Sharp-tailed Grouse, American Woodcock, Mallard (*Anas platyrhynchos*), Wood Duck (*Aix sponsa*), and Ringed-necked Duck are all important for hunting, trapping, and wildlife viewing in the Northwest Sands. There are abundant and diverse populations of many wetland and barrens birds in this ecological landscape that provide bird watching enjoyment for local residents and visitors. Crex Meadows Wildlife Area attracts thousands of visitors during

Significant Wildlife in the Northwest Sands Ecological Landscape

- The Northwest Sands is the best place in the state to manage at multiple scales for pine barrens, a globally rare ecosystem.
- Numerous plants and animals, many of them rare or declining, are strongly associated with pine barrens.
- This ecological landscape offers the best opportunity in the state to manage for the Sharp-tailed Grouse and other area-sensitive barrens species.
- The Trumpeter Swan was first reintroduced to Wisconsin at Crex Meadows and Fish Lake Wildlife Areas, now a core nesting area for this rare bird.
- This is one of only a few areas in Wisconsin where management for the U.S. Endangered Kirtland's Warbler is a practical consideration.
- The U.S. Endangered Karner blue butterfly occurs in good numbers in the southern half of the Northwest Sands Ecological Landscape.
- The generally north-south orientation of major river corridors, such as the St. Croix and Bois Brule, and the relatively unbroken condition of the forests that border them, makes them important for migratory birds and other animals.
- The extensive swamps of northern white-cedar, spruce, tamarack, and black ash found along the upper Bois Brule and St. Croix rivers support boreal birds at their southern range limits.
- The large sedge meadows in the southwestern part of the Northwest Sands provide excellent habitat for Yellow Rail, American Bittern, Northern Harrier, Nelson's and Le Conte's sparrows, Wilson's Phalarope, and many others.
- The large open wetlands here are important breeding and migratory habitat for waterfowl and other waterbirds.
- Alder Thicket supports important species such as wood turtle, Golden-winged Warbler, American Woodcock, and snowshoe hare.
- The rare and locally distributed Connecticut Warbler is locally common where extensive jack pine forests of the appropriate size and age classes exist.
- Many populations of rare dragonflies (e.g., St. Croix snaketail), mussels (e.g., purple wartyback), and aquatic beetles have been documented in the larger rivers, such as the St. Croix, Namekagon, and Bois Brule.
- This ecological landscape is especially important for conserving and managing the Wisconsin Threatened gilt darter.

spring and fall migrations to watch ducks, geese, swans, Sandhill Cranes (*Grus canadensis*), and other birds. The Northwest Sands has a warmwater fishery important to anglers that supports populations of northern pike (*Esox lucius*), muskellunge (*Esox masquinongy*) walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and other panfish. There are many trout streams, which support native brook trout (*Salvelinus fontinalis*), nonnative brown trout (*Salmo trutta*), and rainbow trout (*Oncorhynchus mykiss*). One of the most important salmonid fisheries in the state occurs in the upper Bois Brule River, including species such as brook trout, brown trout, rainbow trout, and coho salmon (*Oncorhynchus kisutch*). Brown and brook trout are found in the Namekagon River north of the City of Hayward. The Clam River, Yellow River, Sawyer Creek, and Beaver Brook have nonnative brown and native brook trout.

Wildlife Habitats and Communities. Many of the rare animals here are associated with habitats that are well represented in this ecological landscape. Managing for the perpetuation of these habitats will help ensure the survival of most of these species. For example, the lakes and rivers of the Northwest Sands support rare fishes, herptiles, aquatic insects, mussels as well as many rare birds associated with and at least partially dependent on waterbodies. Migratory waterbirds make heavy use of lakes and large rivers, especially those that contain dense beds of aquatic vegetation.

The St. Croix River has a diverse fish community, including the Wisconsin Threatened blue sucker (*Cycleptus elongatus*), river redhorse, and gilt darter, and the Wisconsin Special Concern lake sturgeon. The river redhorse also occurs in the Namekagon River. The St. Croix River, from the confluence of the Namekagon River downstream to the confluence with Wolf Creek, has the only known viable population of the Wisconsin Endangered St. Croix snaketail dragonfly and a disjunct population of the southern brook lamprey (*Ichthyomyzon gagei*) (WDNR 2002). The St. Croix River is one of the top smallmouth bass rivers in the nation.

The generally north-south orientation of major river corridors such as the St. Croix and Bois Brule, along with the generally unfragmented condition of the forests that border them, make them highly significant to many migratory birds, and they may be important travel corridors for other species as well. A lengthy portion of the St. Croix River runs just beyond the western boundary of the Northwest Sands (in the Northwest Lowlands Ecological Landscape). The St. Croix's headwaters are in the Northwest Sands, in southern Douglas County, very close to the headwaters of the Bois Brule. The St. Croix River system is of high significance to aquatic biota and is associated with many natural communities that are of excellent quality. The species diversity of fish, mussels, and aquatic invertebrates is very high in this river system. Birds use the river valley habitats during migration, and many species nest there. Both southern and northern bird species are found here (Mossman 1991). "Southern" birds such as Prothonotary Warbler (*Protonotaria citrea*), Northern Cardinal (*Cardinalis cardinalis*), Great Egret (*Ardea alba*), Blue-winged Warbler (*Vermivora cyanoptera*), Cerulean Warbler (*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List), Yellow-billed Cuckoo (*Coccyzus americanus*), Red-shouldered Hawk, Red-bellied Woodpecker (*Melanerpes carolinus*), Louisiana Waterthrush (*Parkesia motacilla*), and Blue-gray Gnatcatcher (*Polioptila caerulea*) are found here; "northern" birds such as White-throated Sparrow (*Zonotrichia albicollis*), Blackburnian Warbler (*Setophaga fusca*), Black-throated Green Warbler (*Setophaga virens*), Northern Parula **(***Setophaga americana*), Yellow-rumped Warbler (*Setophaga coronata*), Northern Waterthrush (*Parkesia noveboracensis*), Alder Flycatcher (*Empidonax alnorum*), Nashville Warbler (*Oreothlypis ruficapilla*), Canada Warbler (*Cardellina canadensis*, listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List), Common Merganser (*Mergus merganser*), Mourning Warbler (*Geothlypis philadelphia*), Common Raven (*Corvus corax*), Pine Warbler (*Setophaga pinus*), and Winter Wren (*Troglodytes hiemalis*) are also found here. Six species breeding along the St. Croix River system were listed as Wisconsin Endangered, Threatened, or Special Concern in 2009: American Bittern, Trumpeter Swan, Osprey, Bald Eagle, Red-shouldered Hawk, and Louisiana Waterthrush (WDNR 2009b).

The pine barrens (and mixed pine-oak barrens habitats) contain a characteristic assemblage of breeding birds, including many grassland birds that are uncommon elsewhere, such as the Sharp-tailed Grouse. Pine barrens habitats are important for herptiles such as the prairie skink (*Plestiodon septentrionalis*), gophersnake (*Pituophis catenifer*), Blanding's turtle, and smooth green snake (*Opheodrys vernalis*). Numerous rare invertebrates occur within the Northwest Sands. The U.S. Endangered Karner blue butterfly is probably the best

The gophersnake (Wisconsin Special Concern) is adapted to conditions in sandy prairie and barrens habitats. Photo by Armund Bartz, Wisconsin DNR.

known. Other rare insects, such as the phlox moth, Leonard's skipper (*Hesperia leonardus*), hoary elfin (*Callophrys polios*), and a globally rare tiger beetle (*Cicindela patruela patruela*) occur in, prefer, or are restricted to the open sandy habitats that are still relatively common in this ecological landscape.

Mammals that are characteristic of open sandy habitats, such as the eastern pocket gopher (*Geomys bursarius*), American badger (*Taxidea taxus*), and the Franklin's ground squirrel (*Spermophilus franklinii*), are found in the pine barrens community in this ecological landscape. The gray wolf has reoccupied the region.

Large sedge meadows and marshes are concentrated in the southern part of the ecological landscape. Some of the open wetlands at sites such as Crex Meadows and Fish Lake State Wildlife Areas are among Wisconsin's best examples of large, hydrologically intact, northern sedge meadow communities. They harbor rare or declining species such as Yellow Rail, Nelson's Sparrow, Le Conte's Sparrow, American Bittern, Bobolink (*Dolichonyx oryzivorus*), and Sedge Wren (*Cistothorus platensis*). Marshes are important for nesting and migrating waterbirds of many kinds, including rare species such as Trumpeter Swan, Wilson's Phalarope, Black Tern, Least and American Bitterns, Nelson's Sparrow, and Red-necked Grebe. Several large wetlands, most notably those within Crex Meadows and Fish Lake State Wildlife Areas, are managed for waterfowl and are important breeding and migratory bird habitat for ducks, geese, swans, and Sandhill Cranes. Crex Meadows has been identified as an Important Bird Area nationally (ABC 2014). This ecological landscape is the best in Wisconsin for nesting Ring-necked Ducks. Wild rice lakes are important breeding and migratory sites for ducks, geese, rails, and other water birds. Marshes and sedge meadows are also critical habitat for herptiles such as the Wisconsin Threatened Blanding's turtle.

Both upland and wetland open habitats in the Northwest Sands are important for sensitive birds. Sample and Mossman (1997) listed three priority grassland landscapes for this ecological landscape: Crex Meadows-Fish Lake complex;

Wilson's Phalarope is a rare resident shorebird that has consistently inhabited some of the large marshes and sedge meadows in the southern part of the Northwest Sands. Photo by Dominic Sherony.

The extensive marshes, wet meadows, barrens, dry forests, and sandy soils of the Northwest Sands provide excellent habitat for the Blanding's turtle. Photo by Brian Collins.

The American Bittern (Wisconsin Special Concern) inhabits large sedge meadows and marshes such as those occurring in the southern portion of the Northwest Sands. Photo by Gary Zahm.

*The Short-eared Owl (*Asio flammeus*, Wisconsin Special Concern) relies on large acreages of open habitats such as sedge meadows, prairies, barrens, and surrogate grasslands. Photo by Jack Bartholmai.*

Small remnant sand prairie and pine barrens communities within dense forest of jack pine on south-facing slope above the St. Croix River. Trade River Barrens, Polk County. Photo by William E. Tans.

Namekagon/Douglas County Barrens; and Moquah Barrens in Bayfield County in the northeastern part of this ecological landscape. These three areas encompass nine individual sites for grassland bird management attention within the Northwest Sands (Sample and Mossman 1997).

The Connecticut warbler is locally common only where extensive jack pine forests of the appropriate size and age classes exist, and the Northwest Sands is one of only a few areas in Wisconsin where future management of the U.S. Endangered Kirtland's Warbler is an ecologically feasible consideration.

Extensive seepage swamps of northern white-cedar, black ash, black spruce, and tamarack that border the steep-sided valleys of the upper Bois Brule River support boreal birds associated with wet coniferous forests. They are represented here by species such as the Black-backed Woodpecker, Olive-sided Flycatcher, Evening Grosbeak, Canada Warbler, and Cape May Warbler.

The alder thicket community, as noted earlier, provides important habitat for rare animals such as the wood turtle and Golden-winged Warbler. An especially significant occurrence of alder thicket borders a long stretch of the upper Bois Brule River. In terms of its size, condition, and context, this site is an outstanding example of this community.

Natural and Human Disturbances

Prior to Euro-American settlement, the vegetation of the Northwest Sands Ecological Landscape was a mosaic of pine barrens, scrub oak savanna ("oak barrens"), open patches of sand prairie, pine forest, sedge meadow, conifer swamp, and marsh. This mosaic has been greatly altered by the human disturbances that followed settlement by Euro-Americans in the mid-1800s. Extensive fire suppression has led to changes in vegetation and natural disturbance regimes throughout the ecological landscape, allowing barrens and other open habitats to succeed to forest.

WISCLAND land use/land cover data from 1992 show that 61% of the ecological landscape (771,460 acres) was forested upland; 6% (73,163 acres) forested wetland; 9% (108,923 acres) nonforested wetland; 9% (113,040 acres) grassland; and 1% (15,581 acres) agriculture (WDNR 1993). Almost 5% (60,607 acres) of the ecological landscape is open water, giving it the third highest percentage of open water of any ecological landscape in the state.

Natural and human disturbances play a significant role in the distribution, organization, and function of ecosystems. Even today, fire, flooding, insect infestation, wind, ice, and hail continue to function as disturbance agents. They act over varying scales of time and space, affecting the characteristics (composition, structure, function, and extent) of ecosystems. In addition to major changes in land use, land cover, and hydrology, humans have recently introduced many nonnative species, some of them highly invasive, both intentionally and inadvertently. The human role in disturbance regimes and impacts is discussed later in the "Invasive Species" section.

Human activities have impacted almost every part of the Northwest Sands at many scales, and to varying degrees of intensity. When considering natural disturbance regimes and how they shaped historical ecosystems, it is also important to consider how recent human activities have affected them. For example, extensive road construction can create corridors by which invasive species may colonize new areas, alter hydrology, and fragment formerly contiguous habitats.

Fire, Wind, and Flooding

The fire regime has changed dramatically since Euro-Americans settlement in the mid-1800s. Prior to Euro-American settlement, large fires occurred relatively frequently, and smaller fires were also common. In the driest portions of the

Northwest Sands Ecological Landscape, where vegetation was dominated by pine barrens or jack pine-oak barrens, experts believe that stand-replacing fires occurred at roughly 25- to 50-year intervals, along with low-intensity surface fires at intervals of two to four years (A. Haney, University of Wisconsin-Stevens Point, personal communication). Since Euro-American settlement, major fires in this ecological landscape still occur on occasion. Present-day fires are typically ignited by humans and can spread and develop into large fires in areas with dry fire-prone vegetation and sandy soils that lack firebreaks such as streams, lakes, and wetlands (Cardille et al. 2001). For example, in 1980 an 11,000-acre wildfire swept through a jack pine area near Spooner. For the most part, though, wildfires today are now smaller, mainly due to fire suppression policies and suppression activities. The beneficial use of fire through controlled burns is limited by staffing, suitable weather conditions, public perceptions, safety considerations, and funding.

Studies by Radeloff et al. (2000) of the fire regime in the Northwest Sands prior to Euro-American settlement revealed that the pine barrens occurred in three distinct sub-regions. Some areas supported young, dense jack pine stands while others featured scattered pines or interspersion with other tree species. This difference was due to a relationship between the serotiny level of jack pine cones and the intensity and size of the fires in each sub-region. In the northern sub-region, more mesic conditions of surrounding forests and hillier topography resulted in less frequent crown fires, resulting in mixed forests dominated by red, eastern white, and jack pine. The central sub-region was strongly dominated by jack pine, indicating more frequent crown fires that favored perpetuation of that species. In the southern sub-region, fires were frequent but less intense, creating open savannas of red pine and oak, with lower densities of jack pine than in the other sub-regions.

Severe weather can also have profound impacts on forests. Drought, wind, ice, and hailstorms perpetuate a dynamic cycle, sometimes on a large scale. Two or more consecutive years of drought are often followed by some of the larger and more intense wildfires in the region (Clark 1990). Severe weather events such as hail and intense wind storms impact forest communities, which may then be subject to salvage harvesting and conversion to plantations. For example, in July 2000 a severe hailstorm pelted approximately 5,000 acres in the southern portion of the Brule River State Forest, resulting in large-scale tree damage and significant tree mortality. In the hardest-hit areas, stands of quaking aspen, red pine, jack pine, some hardwoods, and especially swamp conifers were devastated by the event. Hail damage negatively affected growth rates of damaged trees and tree regeneration trends and changed bird species composition on some of the affected sites (Matula 2005).

This structurally distinctive variant of the Pine Barrens community was dominated by huge red pine (note human figure in left foreground for scale) and characterized by an open understory. Frequent fires of relatively low intensity maintained barrens of this type. No similar examples are known today. Image from St. Croix Trail Country: Recollections of Wisconsin *by William Gray Purcell (University of Minnesota Press 1967). Copyright 1967 by the University of Minnesota.*

Hail severely damaged this stand of jack pine during an August 2000 storm. The living conifers in the understory are mostly balsam fir. Several Black-backed Woodpeckers were noted in the dead and dying pines almost immediately after the storm. Photo by Eric Epstein, Wisconsin DNR.

The extent and frequency of flood disturbance prior to Euro-American settlement is unknown. Wetlands and the permeable sandy soils in this ecological landscape may mitigate local flooding by rapidly absorbing precipitation. However, some stretches of the major rivers such as the St. Croix, Namekagon, and Bois Brule would have flooded periodically.

Weather, especially precipitation cycles, also has significant effects on wetland and shoreland communities. Fluctuations in available precipitation influence both the structure and composition of vegetation because areas that are dry one year may be totally inundated in other years. Following significant drops in the local water table and lake levels, the exposed and unvegetated shorelines of some seepage lakes in this ecological landscape are quickly colonized and revegetated by highly specialized plants, some of them very rare. These sprout from propagules that lie dormant in the seed bank, awaiting appropriate conditions.

Forest Insects and Disease

Periodic insect infestation that causes tree mortality is one precursor to fire. Jack pine budworm infestations can cause large-scale mortality of mature jack pine, increasing fuel loads. As with fire, this disturbance agent is characteristic of this ecological landscape. Typically, jack pine budworm outbreaks occur about once a decade and can last two to four years (Weber 1993). An outbreak occurred in 1992 and 1993, affecting 90% of the jack pine forests in the Northwest Sands. Another outbreak occurred in 2005**.** Salvage logging occurred on 27% of the infested mature jack pine stands during the 1992–93 outbreak (Radeloff 2000). Salvage harvest in some ways resembles the effects of fire; both can be large-scale disturbances that occur after an insect outbreak. However, fire reduces not only canopy density but also the density of saplings, shrubs, and herbaceous litter. Fire also mineralizes organic material, making nutrients available to plants, whereas logging removes those nutrients.

Periodic decline and death of oaks occur in the Northwest Sands Ecological Landscape. These outbreaks, variously named oak decline, oak dieback, or oak mortality, are caused by a complex interaction of environmental stresses and forest insects and diseases. Trees are weakened by environmental stresses such as drought and late spring frosts or by defoliating insects. Weakened trees then show progressive dieback from the crown and then finally succumb to other diseases such as the fungi *Armillaria*.

There are a variety of other insect and disease agents in the major forest covertypes. Eastern white pine is susceptible to white pine blister rust (*Cronartium ribicola*). Red pine is susceptible to pine blight fungus (*Diplodia pinea*) and pine sawfly (*Neodiprion* spp.*, Diprion* spp.*)*. Oak is susceptible to gypsy moth (*Lymantria dispar*), two-lined chestnut borer (*Agrilus bilineatus*), *Armillaria* fungi, and oak wilt fungus (*Ceratocystis fagacearum*). Aspens can be impacted by forest tent caterpillar (*Malacosoma disstria*), aspen heart rot fungus (*Phellinus tremulae*), and aspen Hypoxylon canker fungus (*Hypoxylon mammatum*). White birch can be affected by bronze birch borer (*Agrilus anxius*). Generally, drought can predispose trees to many diseases and insect attack.

Emerald ash borer (*Agrilus planipennis*) is an exotic insect native to Asia. The black ash-dominated hardwood swamps in this ecological landscape could be seriously affected by the emerald ash borer. This extremely serious forest pest has been confirmed in 35 Wisconsin counties as of 2015, including Douglas County in the Northwest Sands. Affected counties have been placed under quarantine to limit the inadvertent spread of the emerald ash borer, which may be present in ash nursery stock, ash firewood and timber, or other articles that could spread emerald ash borer into other parts of Wisconsin or other states. Some adjacent counties are also under quarantine because of their proximity to infestations in neighboring counties. Attempts to contain infestations in Michigan by destroying ash trees in areas where emerald ash borer was found have not been successful, perhaps because the insect was already well established before it was found and identified. The emerald ash borer typically kills a tree within one to three years. In greenhouse tests, the emerald ash borer has also been shown to feed on some shrub species such as privets (*Ligustrum* spp.) and lilacs (*Syringa* spp.), but it is still unknown as to whether shrub availability will contribute to its spread under field conditions. See the Wisconsin Emerald Ash Borer website (WDATCP 2015) for up-to-date information on its current distribution.

More information about these forest diseases and insect pests of forest trees can be found at the Wisconsin DNR's forest health web page (WDNR 2014a) and at the U.S. Forest Service Northeastern Area forest health and economics web page (USFS 2014).

Invasive Species

Nonnative invasive plants and animals can replace native species and may eventually completely dominate a natural community, decreasing the abundance and diversity of native species. In terrestrial ecosystems, spotted knapweed, glossy and common buckthorns (*Rhamnus frangula* and *R. cathartica*), nonnative honeysuckles (*Lonicera tatarica, Lonicera morrowi, Lonicera* x *bella*), and leafy spurge already pose problems. These species may initially colonize heavily disturbed areas such as roadsides, trails, other rights-of-way, or agricultural areas but can also invade and spread through barrens, sand prairie, and dry forest communities. In aquatic and wetland ecosystems, Eurasian water-milfoil *(Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), flowering-rush (*Butomus umbellatus*), curly pondweed (*Potamogeton crispus*), and rusty crayfish (*Orconectes rusticus*) are found. Common carp (*Cyprinus carpio*) have been documented in this ecological landscape.

The Great Lakes Indian Fish and Wildlife Commission and the Invasive Plants Association of Wisconsin developed a working list of invasive plants for nonnative plants in Wisconsin

(IPAW 2015). This list includes species that can negatively affect wetland plant communities, such as purple loosestrife, common reed, and narrow-leaved or hybrid cat-tails (*Typha angustifolia* and *Typha* x *glauca*). See the Great Lakes Indian Fish and Wildlife Commission website for maps showing purple loosestrife distribution and control efforts, including biological control, in the Northwest Sands Ecological Landscape (GLIFWC 2014a). This website also shows where other invasive plant and animal species occur and where control efforts are taking place within the Northwest Sands. A Wisconsin DNR project in central Wisconsin developed a protocol for mapping wetland areas heavily dominated by reed canary grass from satellite imagery, which could be applied to identify the extent of reed canary grass infestations in emergent/wet meadow and marsh vegetation of this ecological landscape (Bernthal and Willis 2004).

Some purple loosestrife populations are being treated through manual, chemical, and biological control efforts. Control methods are being implemented on a small scale to control leafy spurge and spotted knapweed. At Crex Meadows State Wildlife Area, spotted knapweed has been hand-pulled with some success. In other areas, small patches of leafy spurge have been chemically treated. Such labor-intensive methods are usually reserved for small-scale outbreaks before an invasive species has spread over large areas.

Other species, such as the ruffe *(Gymnocephalus cemuus*), zebra mussel (*Dreissena polymorpha*), and sea lamprey (*Petromyzon marinus*), are potential threats because they have been found in the nearby Superior Coastal Plain Ecological Landscape to the north that is connected to this ecological landscape. Active control methods in streams draining into Lake Superior have proven successful in keeping the sea lamprey out of the Northwest Sands to date. However, sea lamprey barriers on streams are designed to allow passage of trout and salmon but may prevent other species from going upstream. In addition, use of TFM (3-trifluoromethyl-4-nitrophenol) to kill sea lamprey larvae in streams negatively impacts native lamprey species and may have negative impacts on other aquatic invertebrates (e.g., mussels and other benthic fauna).

Combining prevention and education, implementing control methods, research, and strategic planning efforts constitute the current strategies to combat invasive species for many agencies, NGOs, and other landowners. To assist these efforts, the Wisconsin DNR has a manual for controlling nonnative, invasive plants: the *Wisconsin Manual of Control Recommendations for Ecologically Invasive Plants* (Hoffman and Kearns 1997). The Nature Conservancy also has a manual for control of nonnative, invasive plants, the *Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas* (Tu et al. 2001). The Great Lakes Indian Fish and Wildlife Commission offers information on control of invasive species (GLIFWC 2014c). A useful book on the identification and control of invasive plants is *Invasive Plants of the Upper Midwest* (Czarapata 2005).

For more information about invasive species in Wisconsin, see the Wisconsin DNR's invasive species web page (WDNR 2014c).

Land Use Impacts

Historical Impacts. Fire was the major historical disturbance factor in the Northwest Sands Ecological Landscape. Fires were likely set by American Indians as well as started by natural causes such as lightning strikes. The presence of barrens and savannas early in the Euro-American settlement period indicates that fires of varying frequencies and intensities occurred regularly in much of the ecological landscape. The Northwest Sands attracted Euro-American settlers, resulting in activities such as agriculture, logging, and home construction. The ecological impacts of land uses in the latter half of the 19th and the first half of the 20th century were immense, and some of these persist to this day. Two of the largest impacts were clearing land for farming, which removed native vegetation as land was converted to crop fields and pastures, and fire suppression, which allowed open areas and savannas (e.g., pine barrens) to succeed to jack pine or oak forests.

Logging operations used some of the larger waterways to float logs to the mills. Riverways were cleared of large woody material to facilitate navigation, river bottoms and banks were scoured during log drives, and deposition of bark and other woody debris covered the natural substrates, changing the character of many water bodies. The large areas of more open barrens changed to a mix of scattered farms (most of which were unsuccessful because of poor soils and short growing seasons), and dense forests of jack pine or oak. In the 20th century, large drainage projects, as well as the construction of dams and impoundments, altered the physical environments of wetlands and waterbodies, with cascading effects on native vegetation, wildlife, and natural disturbance regimes.

Current Impacts. Current disturbances in the Northwest Sands are largely due to human activities, primarily fire suppression, timber production, and home and infrastructure development**.** Modern fire suppression activities have reduced the extent and frequency of fire but may have increased fire risk and intensity because fuel loads increase beyond what they were under historical fire regimes. Fire suppression has allowed more open vegetation such as barrens and sand prairies to succeed to dense forests of pine, oak, or sometimes aspen.

Human disturbance also includes the long-term conversion of land from naturally occurring vegetation to farm fields (many now abandoned), roads, buildings, and utility corridors. Impoundments, created for hydroelectric production, flood control, or to benefit some species of wildlife (e.g., waterfowl), may flood and alter sedge meadows, bogs, or other native wetland communities, making them more marsh-like. Finally, shorter-term disturbances result from logging and recreational pursuits such as ATV use.

The 2013 Germann Road Fire, covering over 7,000 acres, was Wisconsin's largest forest fire in recent years. Photo by Colin Nowaczyk, Wisconsin DNR.

When well planned, cutovers such as this one can complement management of barrens and other open habitats. Photo by Colin Nowaczyk, Wisconsin DNR.

Major differences between current and historical disturbances are that today's impacts are multiple, pervasive, differ in kind from those of the past, and affect much of the landscape almost continuously. In areas dominated by jack pine and scrub oak and which support the dynamic and structurally variable pine barrens community, disturbance by fire was relatively frequent, sometimes occurred at large scales, and was often "stand replacing." Periodic wildfires were especially important to maintain this fire-adapted vegetation and the many native species that were dependent on it. Periodic outbreaks of jack pine budworm, ice storms, and windstorms also affected (and still affect) the upland vegetation, especially in the more level southern two-thirds of the ecological landscape. Other present disturbances, such as large permanent dams, ditches, excessive nutrient and sediment inputs, herbicide and pesticide use, high white-tailed deer populations, and recent introductions of nonnative invasive species, had never occurred here prior to settlement by Euro-Americans.

Forest Management. Most of the land in the Northwest Sands is now forested (76%), and most of the publicly owned forestland is used to produce pulp and, to a lesser degree, habitat for selected wildlife species. Conversion of "natural" forests and open pine barrens to pine plantations has been common in recent decades. The use of herbicides to aid in the establishment of these plantations can reduce or eliminate native plants and some of the animals dependent on native flora. There may be a threat of groundwater contamination from use of these chemicals in some locations. Instead of developing ***monotypes*** of planted pines, the natural regeneration and perpetuation of jack pine and oak forests can be more beneficial to native plants and animals and still allow for the extraction of forest products. Management practices should be designed to maintain the patch sizes and age structures necessary to support or restore the full complement of native animals and avoid fragmentation, isolation, and simplification of habitats needed by these species. The creation of large amounts of hard edge habitats throughout the ecological landscape has promoted habitat generalists such as white-tailed deer, American Robin (*Turdus migratorius*), Song Sparrow (*Melospiza melodia*), Chipping Sparrow (*Spizella passerina*), and Blue Jay (*Cyanocitta cristata*) at the expense of interior forest or barrens habitat specialists, area-sensitive species, and disturbance-sensitive species. Where feasible and appropriate, "softer," more gradual, "feathered" transitional areas between habitats will support more of the sensitive specialists and reduce some of the negative impacts hard edge can generate.

Agriculture. Although attempts to farm occurred in the Northwest Sands, most farms were unsuccessful. There is currently little agriculture here.

Residential Development. Overall, this area has a large percentage of homes that are used seasonally and/or for recreational use (10%–40%, with over 40% of the seasonal housing in the "lakes" region of Burnett County and on the Bayfield Peninsula (WDNR 2006a). (Most of the residential development on the Bayfield Peninsula is associated with areas near Lake Superior, which is in the adjacent Superior Coastal Plain Ecological Landscape.) Close proximity to the Minneapolis-St. Paul metropolitan area likely contributes to this trend.

Some of the ecological consequences of these residential developments include an increase in habitat generalists and nonnative habitats (e.g., roads, utility rights-of-way, lawns, landscaped areas, golf courses, sand blankets, sand and gravel quarries), feeding of wildlife, introduction of invasive plants, and predation by free-ranging dogs and cats. The placement

Sand-bottomed, deep lakes with clear water are common in several parts of the Northwest Sands. These have attracted people, and many of the larger lakes now have developed shorelines. Photo by Jerry Bartelt, Wisconsin DNR.

of shoreline structures such as piers, boat lifts, and ramps can reduce the amount of nearshore aquatic habitats that are beneficial to fish, herptiles, wading birds, invertebrates, and many other wildlife species. Lakeshore development also contributes runoff containing nutrients, herbicides, and sometimes salt, which reduces water quality.

Changes in Hydrology. Early in the 20th century, there were attempts to drain wetlands in the Northwest Sands for agricultural use. The sandy, drought-prone soil, low soil fertility, and frequent growing season frosts made agriculture in most parts of the Northwest Sands unsuccessful. Many farms were abandoned following severe or prolonged droughts and poor crops. In addition to wetland drainage, wetlands have been altered by flooding to provide waterfowl habitat. Converting wetland habitat from one type to another, such as changing sedge meadow to marsh, is not necessarily an improvement, and it can diminish or eliminate habitat for species dependent on the "converted" habitat. While it is still a wetland, it may have fewer, or very different, functional values than the original wetland.

At the ecological landscape level, all native wetland types should be maintained in an appropriate range of patch sizes and protected from direct or indirect activities that diminish their quality and function. Changing wetland hydrology by lowering the water table and eliminating periodic fire can cause sedge meadow and other open wetlands to succeed to shrub swamp or forest (WDNR 2001).

Dams were constructed to generate power, facilitate water transportation, and create recreational opportunities. Dams limit the movement of aquatic organisms, including the movements of fish such as lake sturgeon, walleye, smallmouth bass, and other species. They also change rivers and streams into artificial lakes, which have far different properties than the flowing waters.

Management Opportunities for Important Ecological Features of the Northwest Sands Ecological Landscape

Natural communities, waterbodies, and other significant habitats for native plants and animals have been grouped together as "ecological features" and identified as management opportunities when they

- occur together in close proximity, especially in repeatable patterns representative of a particular ecological landscape or group of ecological landscapes;
- offer compositional, structural, and functional attributes that are important for various reasons and that are not likely to be represented in a single stand;
- represent outstanding examples of natural features characteristic of a given ecological landscape;
- are adapted to and somewhat dependent on similar disturbance regimes (e.g., periodic fire);
- share hydrological linkage;
- increase the effective conservation area of a planning area or management unit, reduce excessive edge or other negative impacts, and/or connect otherwise isolated patches of similar habitat;
- potentially increase ecological viability when major environmental or land use changes or shifts occur by including environmental gradients and connectivity among other important planning and management considerations;
- accommodate species needing large areas or those requiring more than one habitat;
- add habitat diversity that would otherwise not be present or maintained; and
- provide economies of scale for managers. Managing larger areas does not necessarily increase management costs—it can do quite the opposite.

A site's conservation potential may go unrecognized and unrealized when individual stands and habitat patches are always managed as stand-alone entities. A landscape-scale approach that considers the context and history of an area, along with the types of communities, habitats, and species present, may provide the most benefits over the longest period of time. This does not imply that all of the communities and habitats associated with a given opportunity should be managed in the same way, at the same time, or at the same scale. We suggest that planning and management efforts on some larger properties and conservation projects incorporate broader considerations and address the diversity of scales and structures that approximate the ***natural range of variability***

in a given ecological landscape, with attention given to those features that are missing, declining, or at the greatest risk of disappearing over time.

Both ecological and socioeconomic factors were considered when identifying management opportunities. Better integration of ecological management with socioeconomic activities can result in efficiencies in the use of land, tax revenues, and private capital. This type of integration can also help generate broader and deeper support for sustainable ecosystem management. Statewide integrated opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management."

Significant ecological management opportunities that have been identified for the Northwest Sands Ecological Landscape include

- pine-oak barrens;
- dry forests of jack pine, red pine, scrub oak;
- wetlands (sedge meadow and marsh);
- inland lakes (seepage lakes, drainage lakes);
- river corridors; and
- miscellaneous opportunities (inland beach, dry-mesic white pine-red pine forest, acid peatlands, ponds, scattered rare species populations).

Natural communities, community complexes, and important habitats for which there are management opportunities in the Northwest Sands are listed in Table 17.3. The map "Ecologically Significant Places of the Northwest Sands Ecological Landscape" in Appendix 17.K at the end of this chapter shows the locations of some areas in which these opportunities occur.

Pine Barrens, Oak Barrens

The pine barrens community (as well as oak barrens and the ***oak grub***-dominated brush prairie) merits management emphasis in the Northwest Sands. This is arguably the best place on the North American continent to manage for this globally rare community type. Large-scale barrens management is possible here because of the suitability of the land, historical conditions, the presence of numerous remnants, and substantial public ownership.

Pine barrens communities of northwestern Wisconsin historically included oak groves and variable densities of pines. In addition to managing for a range of patch sizes, it is desirable to include all structural and compositional stages of barrens, including not only open, "treeless" barrens and "brush prairie" but also oak or pine savannas (with scattered larger trees) and sites with scattered, denser stands of pine or oak interspersed with herb and shrub-dominated openings. In addition, the restoration of large connected landscapes that include pine-oak barrens and wetlands (especially the more open sedge meadows, marshes, and bogs) will benefit the area-sensitive species that occur here.

Outstanding Ecological Opportunities in the Northwest Sands Ecological Landscape

- The Northwest Sands is the best place in the Upper Midwest to manage for globally rare pine and oak barrens communities and the numerous rare species associated with them.
- Dry forests are abundant and offer excellent opportunities to manage for jack pine, red pine, scrub oak and their associates.
- At some locations it should be possible to manage barrens and dry forests compatibly at larger scales.
- Managing dry forest to emulate landscape patterns and the age-class structure created by natural fire disturbance may help alleviate budworm outbreaks in jack pine forests.
- Some of Wisconsin's largest and least disturbed sedge meadows occur in the southwestern part of the Northwest Sands where they provide critical habitat for rare birds.
- Large marshes provide important habitat for migratory and resident birds and many other wetland inhabitants.
- The corridors of the St. Croix, Namekagon, Totagatic, Bois Brule, and Eau Claire rivers merit special conservation consideration because of the diverse aquatic biota they support, the extensive intact associated riparian habitats, and their excellent water quality.
- Lakes are abundant in parts of the Northwest Sands Ecological Landscape.
- Soft-water seepage lakes provide high quality lacustrine and ***littoral zone*** habitats for specialists, including rarities.
- The Inland Beach community is well represented but under-surveyed here and needs more attention.
- Acid peatlands, especially black spruce swamps, occupy poorly drained kettle depressions in pitted outwash landforms.
- Dry-mesic forests of white pine-red pine-red oak are uncommon but offer old-growth management potential at scattered localities.

The combined effects of long-term fire suppression, successional processes, and attempts to convert barrens landscapes to more economically productive uses such as agriculture or intensively managed pine plantations have created a current vegetation pattern in which the more open managed barrens remnants are typically embedded within dense forests of pine (often these are plantations composed entirely of trees of the same species and age), oak, or aspen. Much of the structural

Table 17.3. *Natural communities, aquatic features, and selected habitats associated with each ecological feature within the Northwest Sands Ecological Landscape.*

Ecological features[a]	Natural communities,[b] aquatic features, and selected habitats
Pine-oak barrens	Pine Barrens Oak Barrens Sand Prairie Wet Meadow/Marsh Northern Sedge Meadow Surrogate Grasslands Seepage Lake/Pond
Northern dry forests	Northern Dry Forest Northern Dry-mesic Forest
Wetlands	Alder Thicket Black Spruce Swamp Emergent Marsh Emergent Marsh – Wild Rice Floating-leaved Marsh Hardwood Swamp Northern Sedge Meadow Shrub-carr Submergent Marsh Tamarack (Poor) Swamp
River corridors	Northern Wet Forest Northern Wet-Mesic Forest Forested Seep Northern Dry-mesic Forest Alder Thicket Coldwater Stream Coolwater Stream Warmwater River Warmwater Stream
Inland lakes	Inland Beach Inland Lake: Seepage Lake, Drainage Lake Spring Pond Ephemeral Pond Impoundment
Miscellaneous opportunities	Northern Dry-Mesic Forest Open Bog/Poor Fen Inland Beach Rare Species Populations

[a]An "ecological feature" is a natural community or group of natural communities or other significant habitats that occur in close proximity and may be affected by similar natural disturbances or interdependent in some other way. Ecological features were defined as management opportunities because individual natural communities often occur as part of a continuum (e.g., prairie to savanna to woodland, or marsh to meadow to shrub swamp to wet forest) or characteristically occur within a group of interacting community types (e.g., lakes within a forested matrix) that for some purposes can more effectively be planned and managed together rather than as separate entities. This does not imply that management actions for the individual communities or habitats are the same.

[b]See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types.

Pine Barrens community on rolling outwash sands, southern Douglas County. Photo by Mike Mossman, Wisconsin DNR.

This prescribed burn is top-killing a thicket of oak grubs (sprouts), thereby reducing woody cover and stem densities and allowing the more light-demanding biota to flourish. Photo by Robert Hanson, Wisconsin DNR.

variability inherent in the dynamic barrens systems has been suppressed or lost, at least temporarily.

Management Opportunities, Needs, and Actions

- The extensive areas of public land make it possible to permanently or periodically connect existing critical barrens remnants in protected areas by using semi-natural landscapes (e.g., a combination of managed forests and abandoned farms) as linking corridors. Managing at a scale of thousands of acres in a mosaic of barrens, grasslands, wetlands, and forests may be the best way to protect mobile, area-sensitive species and species that need to move around as habitat conditions change. Providing for the periodic movement of barrens-dependent species between some of the now-isolated patches of barrens habitat is a key long-term management consideration.
- There are opportunities to use prescribed fire in concert with other management tools to develop more diverse structural characteristics and to enhance or restore species composition in pine-oak barrens.
- Catastrophic fire will continue to be a significant risk to structures in many parts of the Northwest Sands. Opportunities exist to educate the public about fire risk and to identify areas of greatest hazard, then locate structures away from those areas via proactive local planning. Expanding the education of local landowners at the urban interface (e.g., via the National Fire Protection Association's Firewise program, which is ongoing) could promote the use of appropriate natural landscaping techniques to better protect properties from fire.
- Areas affected by wildfire in the future should be carefully evaluated for both barrens restoration opportunities and the potential for the establishment of fuelbreaks that could reduce future risks to life, property, and forest resources.
- Large firebreaks within the highly flammable jack or red pine forests might be used as corridors to periodically or permanently connect isolated patches of pine barrens.
- Rare plants that are strongly associated with the pine-oak barrens community, and that would likely benefit from barrens management, include dwarf milkweed, silky prairie-clover, crinkled hairgrass, and dotted blazing star.
- The barrens community type, especially in proximity to other open communities and habitats such as sedge meadow, emergent marsh, sand prairie, and abandoned agricultural land (surrogate grassland) make the Northwest Sands one of Wisconsin's most important areas for grassland bird management, including the area-sensitive Sharp-tailed Grouse (Sample and Mossman 1997).
- Crex Meadows and Fish Lake State Wildlife Areas are important management sites for the U.S. Endangered Karner blue butterfly, as documented in its habitat conservation plan (WDNR 2010b). The Northwest Sands is Wisconsin's northwesternmost location for this species.
- Besides the many birds of conservation concern and Karner blue butterflies associated with the barrens habitats of the Northwest Sands, management opportunities are also good or excellent for prairie skink, Blanding's turtle, gophersnake (*Pituophis catenifer*), smooth green snake, Leonard's skipper, hoary elfin, a globally rare tiger beetle (*Cicindela patruela patruela*), eastern pocket gopher, and Franklin's ground squirrel, among many others.

Dry Forests: Jack Pine, Red Pine, Scrub Oak

Dense forests of jack pine, northern pin oak, and bur oak are now widespread and common throughout the ecological landscape. Historically, some of these dry forests included a significant component of red pine, but natural stands of red pine are presently rare here. All three native pine species

have declined significantly since Euro-American settlement, while oaks, which may have existed in a suppressed state or as "grubs" in many parts of the Northwest Sands, have increased significantly on dry sites. Plantation-grown pine, mostly red pine but with some jack pine, is now abundant in many parts of the Northwest Sands. Other tree species that have benefited from fire suppression and forest management practices include trembling aspen and red maple.

Older forests of red pine, eastern white pine, and oaks did occur in certain landscape settings, such as on "islands" within large wetlands; on the lee side of lakes, larger streams, and wetlands; and in areas with relatively rough topography. Such older stands are now very rare, and opportunities to manage for forests with this composition and structure should be considered or planned for on appropriate sites.

The Gordon Rolling Barrens (212Ka11) Landtype Association (a map showing Landtype Associations, along with their descriptions, can be found in Appendix 17.K at the end of this chapter) formerly supported vast forests composed of dense stands of jack pine. Despite the recent conversion of substantial acreage of jack pine forest to red pine plantations, there are many opportunities, at varying scales, to maintain this important forest community in the Northwest Sands. Additional opportunities exist in other Landtype Associations in the Northwest Sands, e.g., in portions of the Grantsburg Dunes (212Ka01) and Bayfield Rolling Outwash Barrens (212Ka04).

An important opportunity and need is to develop better ways to integrate management of forests and barrens. On dry, nutrient poor, fire-prone sites, the barrens openings and the densely forested lands are both expressions of the same ecosystem under different disturbance and management regimes. There is a tendency now to try and maintain vegetation in relatively static compositional and structural conditions, in the same place, over time. Opportunities for more flexible approaches are needed and should be sought.

The conversion of jack pine and oak forests to red pine monotypes continues and results in ecosystem simplification and the long-term loss of habitat for many of the species associated with either barrens or dry forests. Where possible, other forest management options should be considered, especially on state and federal lands. There may also be alternative forest management opportunities on a few of the larger private tracts.

Management Opportunities, Needs, and Actions

- There is ample opportunity to increase the extent of dry jack pine-northern pin oak forest. In places where oak wilt is present and likely to spread, an opportunity exists to plant jack pine beneath the existing oak canopy in areas that were formerly jack pine forest.
- In forests such as those referenced in the preceding bullet, there may also be an opportunity to manage some areas as small patch barrens if the understory composition indicates that this is feasible.
- Emphasize natural forest regeneration techniques and the use of prescribed burning in addition to or instead of creating new plantations. Maintaining small, relatively open patches within managed jack pine forests can help to maintain populations of light-demanding, sensitive native plants, invertebrates, and others.
- Older, intact dry-mesic forests of pine and oak provide habitat for rare plants and animals; this needs to be incorporated into public lands management plans where appropriate.
- Connecticut Warbler and Kirtland's Warbler have management opportunities in jack pine forests as do a number of native finches that specialize in eating conifer seeds.
- Additional techniques are needed to better enable the natural regeneration of red pine forests and mixed red pine-white pine forests.
- Manage stands to emulate landscape patterns and age-class structures created by natural fire disturbance. This may help alleviate the severity of jack pine budworm outbreaks.
- Wolves utilize the area as a major dispersal corridor from Minnesota into Wisconsin and Upper Michigan. The Wisconsin Wolf Management Plan (WDNR 1999b) contains suggested corridor management goals.
- There is an absence of information on the composition and structure of natural red pine stands, making it difficult to describe them in detail and even more difficult to compare them to plantations.
- Wisconsin DNR's Natural Heritage Inventory program has not given the dry forest communities composed of short-lived species such as jack pine and northern pin oak much attention compared with other forest community types. There is a need to expand surveys, data collection, and perform analyses of dry forests to better enable planners, managers, and conservationists to make the best decisions for their various projects and management goals.

Wetlands: Northern Sedge Meadow and Emergent Marsh

The vast sedge meadows found in the southwestern part of the Northwest Sands are particularly important because of their size, condition, intact hydrology, and the many rare species they are known to support. Some of the largest and least disturbed of these meadows occur on state-owned or state-managed lands; they represent some of the most important opportunities statewide to protect and manage this community and its associated biota and should be protected and maintained. The most extensive open meadows and fens are associated primarily with the Grantsburg Dunes (212Ka01) Landtype Association.

Some of the meadows have been diked and partially impounded, primarily to attract and support species of desired waterfowl. To a point, this practice will support many species of conservation concern. In recent years, common reed has

been showing up in some of the impounded "sedge-marshes." Common reed should be monitored carefully because it has the potential to take over large areas of shallow marsh and when dominant can greatly reduce habitat diversity and suitability for desired species, including many native wetland plants. Nonnative invasive cat-tails (*Typha angustifolia* and the hybrid *Typha* x *glauca*) also bear close watching.

Good examples of several kinds of marsh community, including Emergent Marsh, Wild Rice Marsh, Floating-leaved Marsh, and Submergent Marsh, occur as important components of the wetland vegetation mosaic in the Northwest Sands. Marshes may develop along sluggish stretches of large rivers, on the margins of lakes, or in shallow basins that receive nutrients from the surrounding watershed via overland flow, an inlet stream, or groundwater. Some of the larger marshes in the Northwest Sands occur along impounded portions of rivers or streams. In past years, the extensive emergent marsh at the Gordon Flowage on the St. Croix River in southern Douglas County supported breeding populations of sensitive marsh specialists such as Marsh Wren (*Cistothorus palustris*), Yellow-headed Blackbird, Least Bittern, and Black Tern.

Large numbers of migratory waterbirds make use of the marshes in this ecological landscape, including ducks, geese, swans, cranes, cormorants, loons, grebes, rails, gulls, terns, and herons. Sites such as Crex Meadows and Fish Lake State Wildlife Areas attract large numbers of people for wildlife viewing during the spring and fall migration periods.

Excellent examples of Wild Rice Marsh occur at several locations in the Northwest Sands. Wild Rice Marshes are well represented here compared to most other ecological landscapes. The rice marshes are highly significant, ecologically and culturally and warrant strong protection.

Management Opportunities, Needs, and Actions

- Emergent marshes and wild rice lakes create important management opportunities for Trumpeter Swan, Wilson's Phalarope, Least and American Bitterns, Red-necked Grebe, Sandhill Crane, and large numbers of ducks and geese.
- The large sedge meadows in the southern part of the ecological landscape present excellent opportunities to maintain breeding populations of species such as Wilson's Phalarope, American Bittern, Yellow Rail, Northern Harrier, Nelson's Sparrow, and Le Conte's Sparrow.
- Sedge meadows and marshes that have been affected by dike or ditch construction need to be monitored to assess the degree and direction of future vegetation changes.
- More detailed sampling and better characterization of the sedge meadow flora is desirable to provide a baseline on stand composition and structure.
- Knowing the disturbance histories of a subset of the sedge meadows would help to clarify the type, magnitude, and timing of disturbances that have played significant roles in shaping and maintaining them.
- Some of the largest meadows are in close proximity to barrens restoration and management areas, providing benefits to area-sensitive animals dependent on large open landscapes as the effective conservation area for at least some of these species has been increased.
- Emergent aquatic plants, including aggressive nonnative species such as narrow-leaved cat-tail and common reed, are well established at several important sites now supporting intact sedge meadows and emergent marshes. The trends of these invaders should be monitored carefully, using both remote sensing and ground-truthing techniques. It is desirable to begin this soon.
- Work with private and public owners of sedge meadows outside of state wildlife area boundaries to develop agreements and management plans that will maintain the meadows and their sensitive species over time. Work toward ensuring that wetlands do not receive excessive inputs of sediments or nutrients from land use practices on adjoining uplands.
- Additional field surveys are needed to better document the plants and animals of the large meadows in the southernmost part of the Northwest Sands, south of Fish Lake State Wildlife Area.
- Identify potential wetland restoration opportunities and priorities where wetlands have been drained or damaged by other means.

Inland Lakes: Seepage Lakes, Drainage Lakes

The Northwest Sands harbors significant concentrations of glacial kettle lakes. These provide high quality habitats for aquatic organisms, for resident and migratory birds, and for many other species that make use of lacustrine ecosystems. Soft-water seepage lakes are especially common here, and some of these lakes support dense beds of submergent, floating-leaved, and emergent aquatic vegetation. A few of these lakes are known to support populations of unusual plants collectively referred to as coastal plain disjuncts because their core ranges of these plants are in the Atlantic Coastal Plain region of the eastern United States. The strand flora of some Northwest Sands seepage lakes also includes other habitat specialists, some of them quite rare. Additional protection of undeveloped lakes should be a priority conservation action in the Northwest Sands, but more systematic and comprehensive ecological inventories are needed to enable prioritization and selection of potential protection projects.

Development pressure on lakes here is high because of their intrinsic aesthetic appeal and their proximity to the Twin Cities. Small lakes are now facing more intense development pressure as larger lakes become more fully developed, and smaller lakes are also experiencing the impacts of watershed-level land use changes associated with growing human populations, including parcelization of some large single-owner holdings.

Lakes are unevenly distributed in the Northwest Sands. Seepage lakes are common features in the following Landtype Associations: Bayfield Rolling Outwash Barrens (212Ka04); Webb Lake Collapsed Barrens (212Ka05); Siren Plains (212Ka09); Gordon Rolling Barrens (212Ka11).

Management Opportunities, Needs, and Actions

- An inventory of lakes is needed for the Northwest Sands Ecological Landscape and should include the identification and assessment of undeveloped lakes, high quality aquatic habitats, associated habitats such as beaches, sedge meadows, bogs, and conifer swamps, and any high conservation priority plants and animals known to occur in such habitats. The Wisconsin Wildlife Action Plan (WDNR 2005c) can be used to help identify target animal species.
- The protection of undeveloped lakes and shorelines and sites with high water quality deserve priority attention in the Northwest Sands.
- Seepage lakes that experience natural periodic water level fluctuations may periodically create ideal habitat for rare plants associated with undeveloped shorelines, including slender bulrush, Torrey's bulrush, and rugulose grape fern. Several extremely rare plants, such as Fassett's locoweed and alpine milk-vetch, have been documented in the sand and gravel strand zones of seepage lakes just to the east of the Northwest Sands.
- Identify impacts on water quality from shoreline habitat changes due to the increase in shoreline development, home building, and road construction.
- Inappropriate use of ATVs, ORVs, and horses has damaged sensitive shoreline vegetation on seepage lakes on public lands in the Northwest Sands. Agency stewards and others need to address this problem more effectively. Shorelines, highly erodible sandy slopes, and other sensitive areas require additional protection from uses that can damage native plants, increase sedimentation, and spread invasive plants.

River Corridors

The St. Croix, Namekagon, Totagatic, Bois Brule, and Eau Claire rivers warrant special attention because of their generally excellent water quality and the exceptional aquatic biota that is associated with and dependent on them. Maintaining these rivers, their corridors, and associated habitats in an intact, unfragmented condition is a primary conservation consideration for the Northwest Sands Ecological Landscape. In addition, the headwaters of several important coldwater streams that flow to Lake Superior occur in the northernmost portion of this ecological landscape originate in the deep sands of the northern Bayfield Peninsula and also warrant protection.

The extensive northern white-cedar-dominated conifer swamp bordering many miles of the upper Bois Brule River is one of Wisconsin's outstanding examples of this natural community and merits strong protection. Groundwater seepage feeds this conifer swamp, and the biota includes large populations of many rare plants (e.g., fairy-slipper orchid, sheathed sedge, small yellow lady's-slipper, bog bluegrass, Lapland buttercup, and northern black currant) and several rare invertebrates. It is also rich habitat for boreal birds, including the Black-backed Woodpecker, Olive-sided Flycatcher, Cape May Warbler, and various other boreal wood warblers.

An outstanding occurrence of the Alder Thicket community borders a long stretch of the upper Bois Brule River, paralleling the downslope side of the conifer swamps. It deserves protection due to its size, condition, and context. It supports rare plants such as sheathed sedge, lesser wintergreen, and arrowhead sweet-colts-foot; rare animals such as the wood turtle and Golden-winged Warbler; and other animals of conservation concern such as Veery, American Woodcock, and snowshoe hare.

Other rivers and streams are also associated with important wetland communities, including emergent marsh, sedge meadow, alder thicket, conifer swamp, hardwood swamp, and in a few localities, floodplain forest. Maintaining the integrity and connectivity of these wetlands is necessary to maintain high water quality in these rivers and streams, provide stable habitat for sensitive aquatic organisms, and retain or restore the ecological connections between significant habitats within and between ecological landscapes.

Management Opportunities, Needs, and Actions

- The maintenance and restoration of ecological function in the St. Croix, Bois Brule (northern white-cedar swamp, recharge areas, and spring management), Namekagon, and Eau Claire river systems, streams, springs, spring ponds, or spring creeks, and conifer swamps present exceptional ecological management opportunities.

The upper Brule River is fed by numerous springs and meanders in languid fashion through an extensive acreage of northern white-cedar swamp and alder thicket. This river system has unique properties and biodiversity values are exceptionally high. Photo by Eric Epstein, Wisconsin DNR.

- Provide ***buffer*** areas to protect spring ponds, which are important and reliable sources of clean, highly oxygenated water for coldwater streams, support trout reproduction, and provide habitat for several rare plants and animals.
- Reducing the impacts of herbivory by maintaining lower white-tailed deer populations at sites with browse-sensitive vegetation could potentially increase the viability of important plant species, including northern white-cedar and important herbaceous associates such as orchids and lilies.
- There are many opportunities for research and monitoring to better understand the life histories and habitat needs of rare species, such as the rare invertebrates of the St. Croix-Namekagon River system and the rare plants occurring along the upper Bois Brule River.
- Black-backed Woodpecker, Olive-sided Flycatcher, Evening Grosbeak, and Cape May Warbler are boreal birds that are residents of conifer-hardwood swamps along the Bois Brule and upper St. Croix rivers. Periodic surveys are needed to document their continued presence, along with changes in numbers, geographic shifts in populations, and changes to vegetation. Surveys for some of these species can be combined with standard breeding bird survey methods already in use.
- Golden-winged Warblers occur in wet shrub habitats at many locations (e.g., in the extensive alder thickets along the upper Bois Brule River).
- White-tailed deer impacts need to be systematically monitored in the northern white-cedar swamps along the upper Bois Brule River and perhaps elsewhere.

Miscellaneous Opportunities: Inland Beach, Northern Dry-mesic Forest, and Acid Peatlands

Inland Beach communities have relatively high potential to support rare species that inhabit the sand and gravel littoral zones of certain lakes and, more rarely, streams. Fluctuations in water levels set back succession and during periods of low water create conditions for specialized plants and animals adapted to quickly exploit the newly exposed habitats. Few extensive inventories have been conducted in these habitats in the Northwest Sands ecological landscape.

Northern Dry-mesic Forests, composed of species such as eastern white pine, red pine, northern red oak (*Quercus rubra*), and red maple, are not common here but they are present and unlike some of the drier types, they do have old-growth and ***old forest*** management potential. This forest community occurs at scattered locations throughout the Northeast Sands Ecological Landscape. They are best developed where soil moisture and nutrient availability is higher than on the droughtier low nutrient sands that are prevalent over much of the Northwest Sands. Natural firebreaks such as lakes and streams historically helped determine the distribution and abundance of this type. For example, in the rough rolling topography of the Bayfield Peninsula, both eastern white and red pines were well represented in the historical forests, and remnants of these cover types still occur there. Intact older stands are rare and restricted to small patches at only a few sites, mostly on state or federal lands. The best opportunities to manage and protect Northern Dry-mesic Forest communities are highly localized in parts of the Washburn District of the Chequamegon-Nicolet National Forest in Bayfield County, along the slopes of the Bois Brule River valley in Douglas County, and along the St. Croix River within the St. Croix-Namekagon National Scenic Riverway in Burnett and Polk counties. Those management opportunities identified to date outside of the major public lands are generally small and isolated, though there are several exceptions and in these cases locally active NGOs can play important conservation roles. Landtype Associations that historically supported significant acreages of this forest community, and where the physical environment remains relatively well suited to its restoration include Spooner Plains (212Ka03); Bayfield Rolling Outwash Barrens (212Ka04); Webb Lake Collapsed Barrens (212Ka05); and Siren Plains (212Ka09).

Acid conifer swamps of black spruce and tamarack (Northern Wet Forest) are widespread and common in areas of pitted outwash where lakes and poorly drained kettle depressions are important landscape features. They are less abundant here than in some other northern Wisconsin ecological landscapes. Important Landtype Associations for Black Spruce and Tamarack Swamp are similar to those that contain clusters of lakes and wetland depressions and include Bayfield Rolling Outwash Barrens (212Ka04); Webb Lake Collapsed Barrens (212Ka05); Siren Plains (212Ka09); Gordon Rolling Barrens (212Ka11).

Management Opportunities, Needs, and Actions

- Additional survey work is needed to better document the abundance and composition of inland beaches in the Northwest Sands Ecological Landscape.
- Development pressures on shoreline environments are presently high and increasing, thus there is some urgency in locating and protecting those beach communities that are especially significant to habitat specialists strongly associated with this type.
- Dry-mesic forests composed of eastern white pine, red pine, and northern red oak are uncommon here but do occur at scattered locations across this ecological landscape. This is one of the few terrestrial forest communities that offers high potential for old-growth and old forest management.
- To maintain white pine-red pine-oak communities in working forests and where appropriate elsewhere, a combination of extended rotations, prescribed burning, and shelterwood harvest techniques may succeed. These methods are effective in setting back competition from red maple and aspen and can enhance natural oak and

pine regeneration. Maintaining characteristic structural elements of old-growth and old forest for this type is also an important management goal, especially on lands dedicated to conservation.

- The initiation of salvage logging due to oak decline may present an opportunity to plant eastern white pine, red pine, or jack pine beneath the existing oak canopy in areas that formerly supported these now diminished species in some forests of the Northwest Sands.
- More comprehensive survey work is needed to identify stands of black spruce/tamarack that are of high conservation value, especially those that are large, hydrologically intact, associated with other significant wetland communities and upland forests dominated by conifers, and of potential importance to sensitive species.
- Other acid peatlands, including Open Bog, Muskeg, and Poor Fen communities, are also in need of additional survey work throughout much of this ecological landscape. Large, undisturbed, hydrologically intact stands would be the highest priorities for survey work in the near future.
- Small ponds (these are usually seepage lakes, or less commonly, spring-fed ponds of less than 10 acres) are abundant here but have not been systematically surveyed to evaluate their individual and aggregate significance to plants, invertebrates, herptiles, birds, and others.

Socioeconomic Characteristics

Socioeconomic information is summarized within county boundaries that approximate ecological landscapes unless specifically noted as being based on other factors. Economic data are available only on a political unit basis, generally with counties as the smallest unit. Demographic data are presented on a county approximation basis as well since they are often closely associated with economic data. The multi-county area used for the approximation of the Northwest Sands Ecological Landscape is called the Northwest Sands counties. The counties included are Bayfield, Burnett, Douglas, and Washburn counties because at least 25% of each county lies within the ecological landscape boundary (Figure 17.11). Small portions of Polk and Sawyer counties are also in this ecological landscape, but no socioeconomic data from these counties are included in this section.

History of Human Settlement and Resource Use

American Indian Settlement

The archaeology of northern Wisconsin is fragmentary and often poorly understood. Given this, there are many gaps in our understanding of the cultural evolution of early peoples in northern Wisconsin. It can be generally said that technology and traditions occurred earlier in southern Wisconsin than

Figure 17.11. *Northwest Sands counties.*

in northern Wisconsin (see Chapter 2, "Assessment of Current Conditions," for a description of the cultural traditions of Wisconsin).

There is little evidence of habitation in the Northwest Sands Ecological Landscape until the middle or late Woodland period (Stevenson et al. 1997). The Clam River peoples of the Late Woodland tradition established themselves in northwestern Wisconsin. They were primarily hunter-gatherers, with wild rice being an important part of their diet. There is little evidence in this ecological landscape for large-scale reliance on corn. In Burnett County, there are a few sites where large dome-shaped burial mounds were constructed. Excavations of the mounds revealed a distinct burial custom in which layers of bone bundles were covered with layers of dirt. These successive layers reached up to 12 feet high. The Chippewa claim the mounds were made by Sioux, whom the Chippewa drove out of the territory in the 17th century (Austin 1964).

Several tribes passed through the Great Lakes Region, some staying longer than others. At the time of Euro-American contact, the Santee Dakota inhabited much of northwestern Wisconsin (Mason 1988). The 1600s was a time of forced relocation for many American Indians. During this time, the Huron tribe took up temporary residence in northwestern Wisconsin after having been forced out of Michigan (Austin 1964). Only the Chippewa established a relatively permanent existence in the Northwest Sands counties. Their hunter-gather lifestyle was influenced by harsh environmental conditions, such as a short growing season and poor soil. For more information on American Indian settlement and impacts, see "Statewide Socioeconomic Assessments" in Chapter 2, "Assessment of Current Conditions."

Euro-American Contact and Settlement

During the 17th century, French fur traders, soldiers, and missionaries began arriving in this region. As a result of Euro-American contact with the American Indian tribes, trading posts, missions, and forts along river routes and lakes were established. During the 1800s, however, the tribes began ceding large areas of land to the U.S. government, and permanent Euro-American settlement began.

Finnish immigrants began to arrive in significant numbers during the 1880s (The Wisconsin Cartographer's Guild 1998). They settled in and around Ashland and Superior and took jobs in factories and on the docks in this region. Agriculture was not prominent in the early history of the Northwest Sands counties.

Early Agriculture

Permanent Euro-American settlement began in the Northwest Sands counties with the founding of Bayfield County in 1848 (NACO 2010). Douglas County was founded in 1854, followed by Burnett County in 1856, and much later, by Washburn County in 1883. In 1850 there were reportedly only five established farms in Bayfield County (ICPSR 2007). By 1870 only 77 farms operated in the three founded Northwest Sands counties, most of them in Burnett County. By 1900 the number of farms in Northwest Sands counties began to grow more rapidly, reaching 2,370 farms, while the population had reached 63,726. Population continued to grow in each of the subsequent decades until reaching a peak of 89,084 in 1920; thereafter population fluctuated and then declined in the Northwest Sands counties. Meanwhile, farm numbers continued to grow, even through the Great Depression, reaching 7,685 farms in 1940 (Figure 17.12). However, farm numbers in the Northwest Sands counties had decreased sharply by 1950 as some marginal farms were driven out of production.

Farms tended to be growing ever smaller on average in the Northwest Sands counties than in the state as a whole until 1950, when average farm size in the Northwest Sands counties shot up to 144.8 acres compared to 137.8 acres statewide. During and following World War II, a combination of the failure of many smaller marginal farms, subsequent consolidation, and mechanization increased the average size of farms in the Northwest Sands counties (Figure 17.13). That trend continued throughout much of the remaining 20th century.

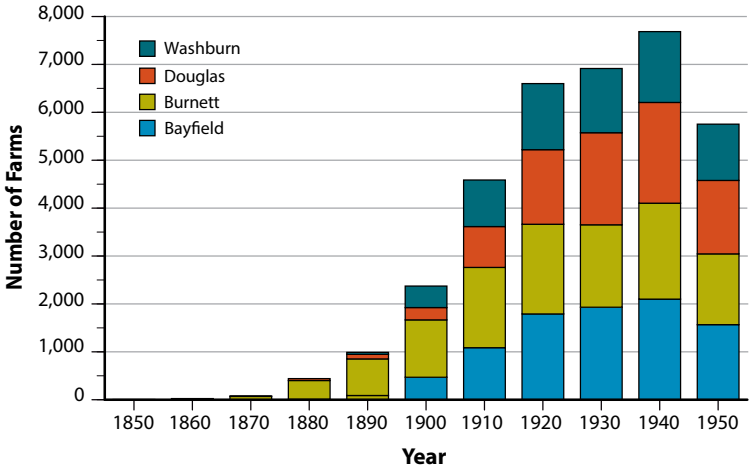


Figure 17.12. *Number of farms in Northwest Sands counties between 1850 and 1950 (ICPSR 2007).*

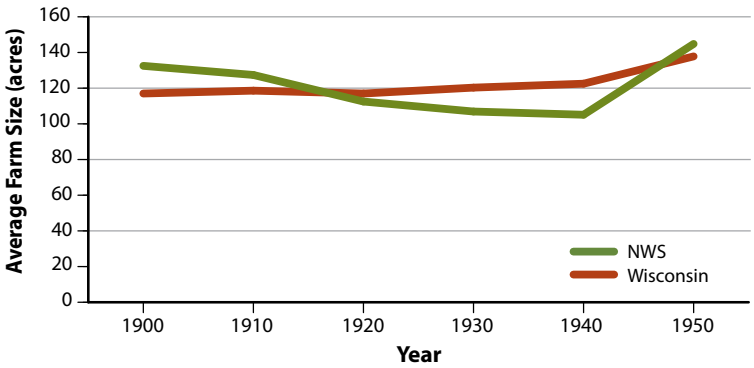


Figure 17.13. *Average farm size in Northwest Sands counties between 1900 and 1950 (ICPSR 2007).*

The total value of all crops indicates the extreme influence of the Great Depression on agriculture. In 1910 all crops harvested in the Northwest Sands counties had an estimated total value of $1.6 million, which increased substantially by 1920 ($8.9 million) (ICPSR 2007). However, total value of all crops in the Northwest Sands counties plummeted in 1930 ($3.7 million) and fell further by 1940 ($2.8 million). Total values of crops in the Northwest Sands counties comprised only 1.6% of total crop value in the state in 1940, and these crops came from farms comprising 3.6% of all Wisconsin farm acreage. Farms in the Northwest Sands counties historically have not been as productive as farms in the state as a whole. See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for further discussion of early agriculture in these northern Wisconsin counties.

Over the early part of the 20th century, the type of farming in the Northwest Sands counties underwent some fundamental shifts as Wisconsin was established as a leader in the dairy industry. Farms in the Northwest Sands counties increasingly grew "hay and forage" crops, and grew less "cereal" crops. The 1910 federal agricultural census listed "cereals" as only 23.1% of the total value of all crops harvested in the Northwest Sands counties (ICPSR 2007). By 1940 cereals comprised only 16.9%. Meanwhile, "hay and forage," associated with livestock farming, was 38.1% of total value of crops harvested in the Northwest Sands counties in 1910 and had risen to 53.7% of total crop value by 1940.

Early Mining

Iron and copper mining drew Euro-American settlers to the Lake Superior region in the mid-1800s. Cornish and Finnish miners were recruited first because of their mining experience in Europe (The Wisconsin Cartographer's Guild 1998). Copper and iron mining did not occur directly within the Northwest Sands counties; rather, this industry took place in surrounding counties. As a result, mining did not have a significant impact on the economy or ecology of these counties. See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for further discussion of the history of mining in Wisconsin.

Early Transportation and Access

Early settlements in Wisconsin generally occurred along main water routes. Access to the area that is now the Northwest Sands counties was gained by navigating the network of lakes and rivers. The four counties encompass both the Mississippi River and Lake Superior watersheds. The St. Croix, Namekagon, and Yellow (Mississippi River) and the Brule and White (Lake Superior) River systems formed the primary water routes through this area.

Two major railroad lines dissected the Northwest Sands counties in the latter half of the 19th century. The Chicago and North Western railroad connected Superior to Chippewa Falls. Northern Pacific (NP), and later, Soo Line (Soo) trains from the west, also stopped in the Superior area before continuing on to Ashland (NP) and Spencer (Soo). Many shortline and short-lived logging railroads were also developed. In the late 1880s and 1890s, some of the earliest of these lines—Drummond and Southwestern Railroad, Washburn and Northwestern, and the Cranberry Lumber Company—were built (Austin 1964).

Early Logging Era

Roth (1898) described forest conditions in some of the northern Wisconsin counties at the close of the 19th century. Roth noted that in Bayfield County pine had been harvested heavily along Lake Superior and along the Namekagon and White rivers in the southeastern third of the county and along the Northern Pacific Railway. Vast expanses of land were burned and barren in the wake of the Cutover. However, a vast pine resource of an estimated 3 billion ***board feet*** remained uncut at the time of Roth's report. The belt associated with the Northwest Sands Ecological Landscape was composed largely of jack and red pine, with eastern white pine a sporadic component. Northern white-cedar, tamarack, and, to a lesser extent, spruce were dominant in the numerous forested wetlands in the southeastern portion of Bayfield County. Birch, American basswood (*Tilia americana*), and maples were the principle merchantable hardwood species, which also totaled an estimated 400 million board feet (Roth 1898). By comparison, today there are an estimated 1 billion board feet of pine, 96 million board feet of eastern hemlock (*Tsuga canadensis*) and over 1.5 billion board feet of hardwood ***sawtimber*** in Bayfield County forests (USFS 2009). Most of the eastern hemlock and hardwood timber is south and east of the Northwest Sands.

Burnett County was described by Roth (1898) as largely barren and devoid of forest cover. The pine had largely been cut over, hardwoods were damaged by fire, and jack pine and red pine dominated the sandy soils. Scattered remnants of pine were estimated to total 200 million board feet. Hardwoods were of poor quality and occurred mostly along the southern edge of the county on sandy loam soils, totaling about 200 million board feet. Jack pine was Burnett County's dominant species, with an estimated volume of 300 million board feet. Tamarack persisted sporadically on otherwise barren (treeless) swamps. By comparison, today there are an estimated 330 million board feet of pine, 64 million board feet of jack pine, and over 695 million board feet of hardwood sawtimber in Burnett County forests (USFS 2009).

Roth (1898) described the northern third of Douglas County (in primarily the Superior Coastal Plain Ecological Landscape) as a boreal mixed forest, with eastern white pine, white birch, yellow birch (*Betula alleghaniensis*), other hardwoods, and some northern white-cedar and tamarack. The forest south of that was similar but with more hardwoods mixed with pines. In the Northwest Sands Ecological Landscape, large jack pine and red pine dominated forests south and east of the St. Croix River. Roth reported the pinery to be cut over along Lake Superior, along the railroads, and along the St. Croix River, but there remained an estimated 3.5 billion board feet of pine in Douglas County. Though hardwoods were reportedly secondary to the forest composition of Douglas County, they comprised an estimated 700 million board feet. Harvests of hardwoods were not heavy, yet oak harvests comprised 25% of the hardwood yield, despite its small share of the forest cover. By comparison, today there are only 328 million board feet of pine and 709 million board feet of hardwood sawtimber in Douglas County forests (USFS 2009).

Washburn County was largely covered by pine prior to the Cutover, but only 350 million board feet of pine remained at the time of Roth's survey. According to Roth, "some of the largest areas of perfectly bare cut and burned-over lands in Wisconsin occur in this [Washburn] county" (Roth 1898). In the wake of the heavy pine cutover, Washburn County hardwoods suffered heavily from forest fires. Roth estimated there were 220 million board feet of hardwoods with large areas devoid of merchantable timber. Together, nearly equal parts American basswood, maple, oak, and birch made up 80% of all hardwood volume. By comparison, today there are 265 million board feet of pine and 683 million board feet of hardwood sawtimber in Washburn County forests (USFS 2009).

Note that the Northwest Sands Ecological Landscape runs diagonally across the four Northwest Sands counties, so the timber summaries by county often include volume from other ecological landscapes. See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for further discussion of the early logging era in northern Wisconsin.

Resource Characterization and Use[1]

The Northwest Sands Ecological Landscape has 1,861 square miles of land area and one of the lowest population densities in the state, 21 people per square mile. There are 95 square miles of surface water here, the vast majority (93%) in lakes.

In terms of current and potential recreational use, there is a much higher percentage of forested land in the Northwest Sands compared to the rest of the state. The Northwest Sands has the third highest percentage of open water among all ecological landscapes and has the second highest proportion of public lands, county, state, and federally owned. The density of campgrounds and multi-purpose trails is above the state average, but the number of visitors to state properties is significantly below average. The density of multi-purpose trails is the highest in the state. The number of Land Legacy sites is low, but the number of sites with high recreation potential is above the statewide average.

Agriculture is not a major factor in the economy of the Northwest Sands Ecological Landscape. It ranks 13th (out of 16 ecological landscapes) in the percentage of land area in agriculture and 14th in net income per farmed acre. This region is far below average in terms of corn and milk production.

Forestry, on the other hand, is much more important to the economy. The Northwest Sands Ecological Landscape has the third highest percentage of its land in forest compared to other ecological landscapes. Forests in the northwest Sands are less productive than in areas with better soils, and volume per acre is the lowest of all ecological landscapes. Removals by volume are about average, however (USFS 2009).

Despite a very low population density, the Northwest Sands Ecological Landscape ranks fourth among ecological landscapes in road density and has five airports, which is about average. There are less than 100 miles of railroad and no ports.

Although the Northwest Sands Ecological Landscape does not use much energy for its low population, it has three hydroelectric power sites and produces 7% of the state's woody biomass. There are no wind or ethanol plants here.

The Land

Of the 1.2 million acres of land that make up the Northwest Sands Ecological Landscape, 76% is forested. About 53% of all forested land is privately owned while 33% belongs to the state, counties, or municipalities, and 14% is federally owned. (USFS 2009).

Minerals

Each of the Northwest Sands counties is currently engaged in nonmetallic mineral extraction. All four counties produce sand and gravel, three counties produce crushed stone, and one county produces cement, lime, and sulfur.

Frac sand mining is increasing dramatically in some areas of Wisconsin due to the increased use of Wisconsin sand in oil and gas extraction in other parts of the country. As of December 2011, there was one frac sand mining or processing plant active in the Northwest Sands Ecological Landscape.

Water (Ground and Surface)

Water Supply

The data in this section are based on the 24K Hydrography Geodatabase (WDNR 2014b), which are the same as the data reported in the "Hydrology" section of this chapter. However, the data are categorized differently here, so the numbers will differ slightly. Surface water covers over 69,000 acres in the Northwest Sands Ecological Landscape, or 5.5% of the total area. The approximately 3,566 lakes (over 1 acre in size) add up to over 56,176 acres, which is 93% of the surface water. Of the 546 named lakes here, 20 lakes are over 500 acres in size, including seven that are over 1,000 acres: Yellow Lake, St. Croix Flowage (on the St. Croix River), Minong Flowage (on the Totagatic River), Big Sand Lake, Clam Lake, Spooner Lake, and McKenzie Lake. Of the 4,295 acres of streams and rivers, the Namekagon, Yellow, and St. Croix rivers are the largest. There are 134 impoundments, covering an area of 29,578 acres.

Water Use

Each day 30.1 million gallons of ground and surface water are withdrawn in the four Northwest Sands counties (Table 17.4; USGS 2010). About 57% of the withdrawals are from surface water. Of the 90,541 people that resided in these counties in 2010, 44% were served by public water sources, and 56% were served by ***private wells***. The largest water usage, about 59%, was for agricultural purposes, with Bayfield County accounting for the bulk of this.

Recreation

Recreation Resources

Land use, land cover, and ownership patterns partly determine the types of recreation that are available to the public. For instance, in the Northwest Sands Ecological Landscape, there is a much higher percentage of forestland and a much lower proportion of agricultural land compared to the rest of the state (see Chapter 3, "Comparison of Ecological Landscapes," and/or the map of "WISCLAND Land Cover (1992) of the Northwest Sands" in Appendix 17.K at the end of this chapter). The surface area in water is third highest among the 16 ecological landscapes, as is the proportion of that water in lakes (Wisconsin DNR unpublished data).

The Northwest Sands has the second highest proportion of public lands, combining federal, state, and county ownerships. The density of campgrounds and multi-purpose trails is above average, but the number of visitors to state properties (in 2004) was far below average (WDNR 2006a). The density of multi-purpose trails is the highest in the state. The number

[1]When statistics are based on geophysical boundaries (using GIS mapping), the name of the ecological landscape is followed by the term "ecological landscape." When statistics are based on county delineation, the name of the ecological landscape is followed by the term "counties."

of legacy sites is low, but the number with high recreation potential is above average (WDNR 2006b).

Supply

Land and Water. There are 958,496 acres of forestland here, or 5.8% of the total acreage in the state (USFS 2007). The Northwest Sands Ecological Landscape comprises 3.4% of Wisconsin's total land area but 5.4 % of the state's acreage in water (see Chapter 3, "Comparison of Ecological Landscapes"). Streams and rivers make up only 6% of the surface water area of the Northwest Sands Ecological Landscape whereas lakes and reservoirs make up over 93% of the area. The largest rivers are the Namekagon, Yellow, and Saint Croix. Yellow Lake and the Saint Croix Flowage cover over 2,000 acres each while the Minong Flowage, Big Sand Lake, Clam Lake, Spooner Lake and McKenzie Lake are each over 1,000 acres (WDNR 2014b).

Public Lands. Public access to recreational lands is vital to many types of recreational activity. In the Northwest Sands Ecological Landscape, almost 608,700 acres, or 48.6% of all land and water, is publicly owned (based on FIA data; USFS 2009). This is significantly higher than the statewide average of 19.5% and ranks second out of 16 ecological landscapes in the proportion of public ownership. There are about 69,100 acres of water, 107,300 acres of state lands, 151,800 acres of federal lands, and 280,500 acres of county lands.

State-owned lands and facilities are important to recreation in the Northwest Sands. There are over 36,900 acres of state forest including parts of the Brule River and Governor Knowles state forests. In addition, there are 59,300 acres in fisheries and wildlife management lands. The largest of these, Crex Meadows and Fish Lake State Wildlife Areas, each provides over 13,000 acres of recreational land (WDNR 2005a).

Trails. The Northwest Sands counties have almost 2,900 miles of recreational trails (Table 17.5) and rank sixth (out of 16 ecological landscapes) in trail density (miles of trail per square mile of land; Wisconsin DNR unpublished data). Compared to the rest of the state, there is a higher density of mountain-biking, ATV, and cross-country ski trails.

Campgrounds. There are 129 public and privately owned campgrounds that provide about 4,300 campsites in the Northwest Sands counties (Wisconsin DNR unpublished data). With 7% of the state's campgrounds, this ecological landscape ranks sixth (out of 16 ecological landscapes) in terms of the number of campgrounds but second in campground density (campgrounds per square mile of land).

Land Legacy Sites. The Land Legacy project has identified over 300 places of significant ecological and recreational importance in Wisconsin, and 13 are either partially or totally located within the Northwest Sands Ecological Landscape (WDNR 2006b). Three of them, the Bois Brule River, the Chequamegon-Nicolet National Forest, and Crex Meadows, are rated as having both the highest recreation and highest conservation significance. In addition, the Danbury to Sterling Corridor, the Namekagon-Brule Barrens, the Namekagon River, and the St. Croix River are rated as having the highest conservation significance.

Table 17.4. *Water use (millions of gallons/day) in the Northwest Sands counties.*

County	Ground-water	Surface Water	Public Supply	Domestic[a]	Agriculture[b]	Irrigation	Industrial	Mining	Thermo-electric	Total
Bayfield	6.0	7.9	0.4	0.5	11.7	0.2	0.2	0.9	–	13.8
Burnett	2.0	0.5	0.3	0.6	1.0	0.4	0.1	0.2	–	2.5
Douglas	1.5	7.7	3.1	0.8	3.6	0.4	1.0	0.3	–	9.2
Washburn	3.4	1.2	0.8	0.6	1.4	1.7	0.1	0.0	–	4.6
Total	**12.9**	**17.2**	**4.6**	**2.4**	**17.8**	**2.7**	**1.4**	**1.3**	**0.0**	**30.1**
Percent of total	**42.8%**	**57.2%**	**15.1%**	**8.1%**	**58.9%**	**8.9%**	**4.6%**	**4.3%**	**0.0%**	

Source: Based on 2005 data from the U.S. Geological survey on water uses in Wisconsin counties (USGS 2010).
[a]Domestic self-supply wells.
[b]Includes aquaculture and water for livestock.

Table 17.5. *Miles of trails and trail density in the Northwest Sands counties compared to the whole state.*

Trail type	Northwest Sands (miles)	Northwest Sands (miles/100 mi^2)	Wisconsin (miles/100 mi^2)
Hiking	66	1.5	2.8
Road biking	104	2.4	4.8
Mountain biking	144	3.3	1.9
ATV: summer & winter	895	20.4	9.3
Cross-country skiing	426	9.7	7.2
Snowmobile	1,206	27.5	31.2

Source: Wisconsin DNR unpublished data.

State Natural Areas. The Northwest Sands Ecological Landscape has about 13,748 acres of ***state natural areas***, all of which is publicly owned (including government and educational institutions; Wisconsin DNR unpublished data). The largest state natural areas in this ecological landscape include Reed Lake Meadow (3,568 acres, Burnett County), Brule Glacial Spillway (2,656 acres, Douglas County), Fish Lake Meadow (1,881 acres, Burnett County), Buckley Creek and Barrens (899 acres, Douglas County), and Mott's Ravine (655 acres, Douglas County). All of these sites are within other public lands. For more information on Wisconsin state natural areas, see the Wisconsin DNR website (WDNR 2014e).

Demand

Visitors to State Lands. In 2004 there were an estimated 215,000 visitors to Governor Knowles and Brule River state forests in the Northwest Sands Ecological Landscape (Wisconsin DNR unpublished data). Crex Meadows Wildlife Area receives over 100,000 visitors each year.

Fishing and Hunting License Sales. Of all license sales, the highest revenue producers for the Northwest Sands counties were nonresident fishing licenses (41% of total sales), resident hunting licenses (22% of total sales), nonresident hunting licenses (17% of total sales) and resident fishing licenses (15% of total sales) (Wisconsin DNR unpublished data). Table 17.6 shows a breakdown of various licenses sold in the Northwest Sands counties in 2007. Burnett County accounts for both the highest number of licenses sold and the highest revenue from sales. This ecological landscape accounts for about 4% of total license sales in the state. However, persons buying licenses in the Northwest Sands counties may travel to other parts of the state to use them.

Metropolitan Versus Nonmetropolitan Recreation Counties. Johnson and Beale (2002) classified Wisconsin counties according to their dominant characteristics. One classification is "nonmetro recreation county." This type of county is characterized by high levels of tourism, recreation, entertainment, and seasonal housing. Three of the four Northwest Sands counties are classified as nonmetro recreation counties: Bayfield, Burnett and Washburn.

Recreational Issues

Results of a statewide survey of Wisconsin residents indicated that a number of current issues are affecting outdoor recreation opportunities within Wisconsin (WDNR 2006a). Many of these issues, such as increasing ATV usage, overcrowding, increasing multiple-use recreation conflicts, loss of public access to lands and waters, invasive species, and poor water quality, are common across many regions of the state.

Silent Sports Versus Motorized Sports. Over the next decade, the most dominant recreation management issues will likely revolve around conflicts between motorized and nonmotorized recreation interests. From a silent-sport perspective, noise pollution from motorized users is one of the higher causes for recreation conflict (WDNR 2006a). Recreational motorized vehicles include snowmobiles, ATVs, motor boats, and jet skis. ATV use is especially contentious. ATV riding has been one of the fastest growing outdoor recreational activities in Wisconsin. There are 895 miles of ATV trails and 1,205 snowmobile trails in the Northwest Sands Ecological Landscape.

Timber Harvesting. A high percentage of people across the state are concerned about timber harvesting in areas where they recreate (WDNR 2006a). They are most opposed to large-scale visual changes (e.g., openings) in the forest landscape. Forest thinning and harvesting that creates small openings are more acceptable. Silent-sport enthusiasts (e.g., hikers, bird watchers) as a group are the most concerned about the visual impacts of harvesting, while hunters and motorized users are somewhat less concerned. However, the attitudes of people within the Northwest Sands Ecological Landscape may differ some from the statewide perspective because of the open nature of many natural communities within this ecological landscape.

Loss of Access to Lands and Waters. With the ever-increasing development along shorelines and continued parcelization of undeveloped lands, there has been a loss of readily available access to lands and waters within the Northwest Sands Ecological Landscape. This may come from the fact that housing developments have become more concentrated with the

Table 17.6. *Fishing and hunting licenses and stamps sold in the Northwest Sands counties.*

County[a]	Resident fishing	Nonresident fishing	Misc. fishing	Resident hunting	Nonresident hunting	Stamps	Total
Douglas	8,092	4,638	902	12,630	1,377	7,158	34,797
Washburn	7,900	11,729	171	9,485	773	2,630	32,688
Bayfield	5,421	6,206	960	5,854	592	5,274	24,307
Burnett	6,308	16,861	214	8,185	1,810	2,319	35,697
Total	**27,721**	**39,434**	**2,247**	**36,154**	**4,552**	**17,381**	**127,489**
Sales	**$637,206**	**$1,725,402**	**$36,331**	**$947,103**	**$728,397**	**$159,335**	**$4,233,774**

Source: Wisconsin DNR unpublished data, 2007.

advent of condominium developments on shorelines that have closed access to large areas of lakeshore once open to the casual recreation user. Another element that may also play into the perception of lost access is the lack of information about where to go. This element was high on the list of barriers for increased outdoor recreation in a statewide survey (WDNR 2006a).

Agriculture

Farm numbers in the Northwest Sands counties decreased 32% since 1970 (USDA NASS 2004). There were approximately 2,630 farms in 1970 and 1,781 in 2002. Between 1970 and 2002, average farm size increased from 191 acres to 225 acres, which is higher than the statewide average of 201 acres. The overall land in farms has steadily decreased since the 1970s (Figure 17.14). In 1970 there were about 498,000 acres of farmland. By 2002, acreage was down to 400,000, a decrease of 20%. Consolidation of farms is only one part of this agricultural ownership and land use change.

For the four counties, the percentage of land in farms ranged from 10% to 19% in 2002, averaging 14% (USDA NASS 2004). The counties with the highest percentage of farm land were Washburn with 19% and Burnett with 17%. In 2002, net cash farm income totaled $9.7 million, or an average of $24 per agricultural acre, much lower than the statewide average of $91 per acre.

In 2002 the market value of all agriculture products sold in the Northwest Sands counties was $49 million (less than 1% of the state total); 31% of this amount came from crop sales, while the remaining 69% was from livestock sales (USDA NASS 2004). Agriculture is not a major part of the economy of any of the four counties in the Northwest Sands.

In 2007, 2,189 acres of farmland had been sold, of which 87% stayed in agricultural use at an average selling price of $2,233 and 13% was diverted to other uses at an average sale price of $4,345 per acre (USDA NASS 2009). Northwest Sands counties have some of the lower priced land in the state, both agricultural and developed.

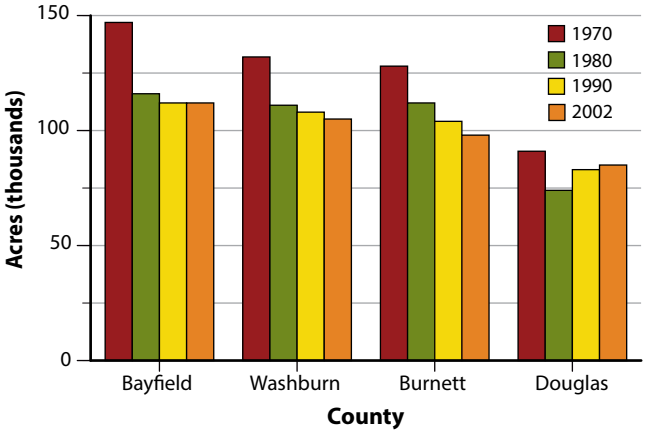


Figure 17.14. *Acreage of farmland in the Northwest Sands counties by county and year (USDA NASS 2004).*

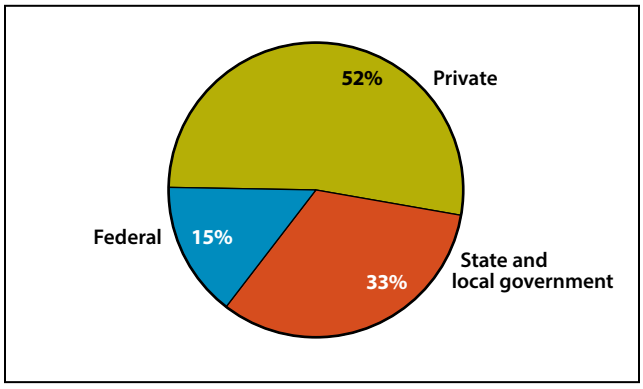


Figure 17.15. *Timberland ownership in the Northwest Sands Ecological Landscape. (USFS 2009).*

Timber

Timber Supply

Based on 2007 Forest Inventory and Analysis (FIA) data, 76% (958,496 acres) of the total land area for the Northwest Sands Ecological Landscape is forested (USFS 2007). This is almost 6% of Wisconsin's total forestland acreage (USFS 2009). Forestland is defined by FIA for timber resource purposes as any land with more than 17% canopy cover. This partially obscures the historical and present condition of the Northwest Sands from an ecological perspective because many of the natural communities were barrens and savannas with more than 17% but less than 50% canopy cover.

Timber Ownership. According to FIA data, of all timberland within the ecological landscape, 52% is owned by private landowners (USFS 2009). Of the remaining timberland, 33% is owned by state and local governments, and 15% is federally owned (Figure 17.15). Timberland is defined as forestland capable of producing 20 cubic feet of industrial wood per acre per year that is not withdrawn from timber utilization (see the glossary in Part 3, "Supporting Materials," for more detailed description of "timberland").

Growing Stock and Sawtimber Volume. There were approximately 917 million cubic feet of ***growing stock*** volume in the Northwest Sands in 2007, or 4% of total volume in the state (USFS 2009). Most of this volume (57%) was in hardwoods (including aspen and oak), much lower than the proportion of hardwoods statewide, which was 74% of total growing stock volume. Hardwoods made up a lower percentage of sawtimber volume, 45%, in the Northwest Sands. In comparison, statewide hardwood volume was 67% of total volume.

Annual Growing Stock and Sawtimber Growth. Between 1996 and 2007, the Northwest Sands counties' timber resource increased by 54 million cubic feet, or 6% (USFS 2009). Approximately 70% of this increase occurred in hardwood volume. Sawtimber volume increased by 473 million board feet, or 24%, again mostly in hardwoods. This increase was

partly a result of an increase in timberland acreage from 912,284 in 1996 to 939,341 acres in 2007 from converting old farm fields to forest. Statewide, timberland acreage increased by 3% during the same time period.

Timber Forest Types. According to FIA data, the predominant forest type groups in terms of acreage are oak-hickory (26%), white, red and jack pines (25%), and aspen-birch (25%), with smaller amounts of spruce-fir, maple-basswood and bottomland hardwoods (USFS 2009) (see Appendix H, "Forest types That Were Combined into Forest Type Groups Based on Forest Inventory and Analysis (FIA) Data," in Part 3, "Supporting Materials"). Acreage is predominantly in the pole and seedling/sapling size classes (37% and 36%, respectively) with the lowest acreage (27%) in the sawtimber size class (Table 17.7).

Timber Demand

Removals from Growing Stock. The Northwest Sands Ecological Landscape has about 4.5% of the total growing stock volume of timberland in Wisconsin. Average annual removals from growing stock were 16 million cubic feet, or about 4.6% of total statewide removals (349 million cubic feet) between 2000–2002 and 2005–2007 (USFS 2009). (See "Socioeconomic Characteristics" in Chapter 3, "Comparison of Ecological Landscapes.") Average annual removals to growth ratios vary by species (major species shown) as can be seen in Figure 17.16. Removals exceed growth for jack pine and black spruce.

Removals from Sawtimber. The Northwest Sands Ecological Landscape has 4.1% of the total sawtimber volume of timberland in Wisconsin. Average annual removals from sawtimber

Table 17.7. *Acreage of timberland in the Northwest Sands Ecological Landscape by forest type and stand size class.*

Forest type[a]	Seedling/sapling	Pole-size	Sawtimber	Total
Aspen	100,317	80,227	25,417	205,961
Post oak-blackjack oak	64,441	32,962	50,435	147,837
Red pine	16,517	38,912	65,407	120,836
Jack pine	39,226	50,486	16,792	106,504
Other pine-hardwood	36,186	18,634	19,402	74,222
Northern red oak	149	22,355	10,160	32,664
Black ash-American elm-red maple	818	23,970	5,900	30,688
White oak-red oak-hickory	4,943	10,961	12,204	28,108
Sugar maple-beech-yellow birch	4,545	12,712	8,739	25,997
White birch	6,501	17,727	–	24,228
Tamarack	10,842	7,803	3,175	21,820
Black spruce	9,739	11,207	–	20,946
Mixed upland hardwoods	19,031	–	1,431	20,462
Red maple-upland	7,856	1,176	3,168	12,200
Eastern white pine	–	–	12,069	12,069
Bur oak	8,097	1,124	1,091	10,312
Nonstocked[b]	–	–	–	7,182
Northern white-cedar	794	–	4,782	5,575
Sugarberry-hackberry-elm-green ash	–	2,464	2,009	4,473
Balsam fir	–	4,356	–	4,356
Chestnut oak-black oak-scarlet oak	–	–	3,315	3,315
Cherry-ash-yellow-poplar	3,231	–	–	3,231
White pine-red oak-white ash	–	2,256	674	2,930
Red maple-oak	–	-	2,842	2,842
White oak	–	2,812	–	2,812
Hard maple-basswood	–	818	1,330	2,148
Black cherry	2,109	–	–	2,109
Balsam poplar	1,963	–	–	1,963
Red maple-lowland	1,554	–	–	1,554
Total	**338,858**	**342,963**	**250,339**	**939,341**

Source: U.S. Forest Service Forest Inventory and Analysis (FIA) Mapmaker (USFS 2009).

[a]U.S. Forest Service Forest Inventory and Analysis (FIA) uses a national forest typing system to classify FIA forest types from plot and tree list samples. Because FIA is a national program, some of the national forest types in the above table do not exactly represent forest types that occur in Wisconsin. For example, neither post oak nor blackjack oak occur to any great extent in Wisconsin, but since there is no "black oak forest type" in the FIA system, black oak stands in Wisconsin were placed in the "post oak-blackjack oak" category in this table.

[b]Nonstocked land is less than 16.7% stocked with trees and not categorized as to forest type or size class.

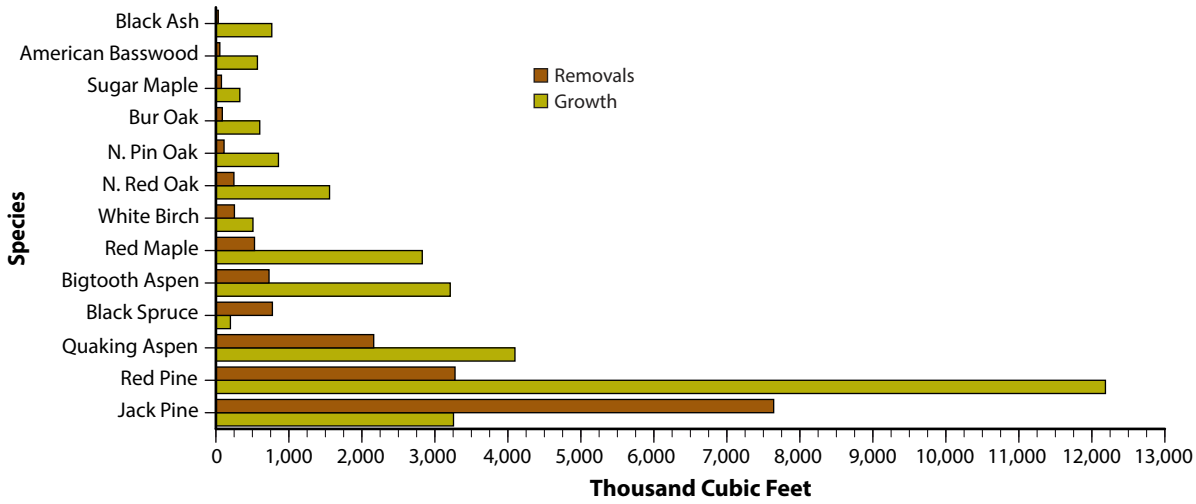


Figure 17.16. *Growing stock growth and removals (selected species) on timberland in the Northwest Sands Ecological Landscape (USFS 2009).*

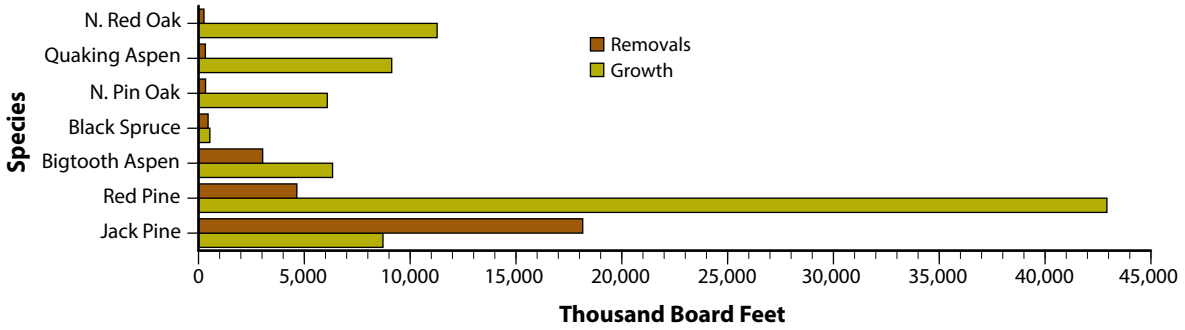


Figure 17.17. *Sawtimber growth and removals (selected species) on timberland in the Northwest Sands Ecological Landscape (USFS 2009).*

were about 27 million board feet or 2.6% of total statewide removals (1.1 billion board feet) between 2000–2002 and 2005–2007 (USFS 2009). Average annual removals to growth ratios vary by species as can be seen in Figure 17.17 (major species shown). Sawtimber removals exceeded growth for jack pine.

Price Trends

In the Northwest Sands counties, sugar maple (*Acer saccharum*), white birch, American basswood, and northern red oak were the highest priced hardwood sawtimber species in 2007 (WDNR 2008). Red pine and eastern white pine were the most valuable softwood timber species. Sawtimber prices for 2007 were generally much lower for hardwoods and similar for softwoods compared to the rest of the state. For pulpwood, oak bolts are the most valuable. Pulpwood values in the Northwest Sands counties were somewhat lower for both hardwoods and softwoods compared to the statewide average.

Infrastructure

Transportation

The transportation infrastructure of the Northwest Sands Ecological Landscape is more developed than the rest of the state in some ways and less developed in others. Road mile density (WDOA 2000) is 16% higher, but railroad density (WDOT 1998) is 45% lower than for the state as a whole. There are five airports (WDOT 2012) in the Northwest Sands Ecological Landscape, none of which are primary regional airports. There are no shipping ports (WCPA 2010) (Table 17.8).

Renewable Energy

Hydroelectric and wind turbine power are the only renewable energy sources quantified by county in Wisconsin energy statistics produced by the Wisconsin Department of Administration (WDOA 2006). General inferences can be drawn from other sources regarding the potential for renewable energy production in the Northwest Sands Ecological Landscape. Other than woody biomass, the Northwest Sands Ecological Landscape has limited potential to produce a significant amount of renewable energy. The Northwest Sands Ecological Landscape has 11% of all woody biomass in Wisconsin, generates 0.7% of hydroelectric power, and produces only 0.5% of the state's corn crop. This ecological landscape does not have any ethanol plants or wind generating sites.

Biomass. Woody biomass is Wisconsin's most-used renewable energy resource. The Northwest Sands counties produce 17.7 million cubic feet of logging residue, or 11% of total statewide production (USFS 2009). Approximately 76% of the Northwest Sands Ecological Landscape is forested. This increased by 3% in the last decade.

Table 17.8. *Road miles and density, railroad miles and density, number of airports, airport runway miles and density, and number of ports in the Northwest Sands Ecological Landscape.*

	Northwest Sands	State total	% of state total
Total road length (miles)[a]	7,329	185,487	4%
Road density[b]	4.0	3.4	–
Miles of railroads	99	5,232	2%
Railroad density[c]	5.3	9.7	–
Airports	5	128	4%
Miles of runway	3.4	95.7	4%
Runway density[d]	1.9	1.8	–
Total land area (square miles)	1,848	54,087	3%
Number of ports[e]	0	14	0%

[a]Includes primary and secondary highways, roads, and urban streets.
[b]Miles of road per square mile of land. Data from Wisconsin Roads 2000 TIGER line files (data set) (WDOA 2000).
[c]Miles of railroad per 100 square miles of land. Data from 1:100,000-scale Rails Chain Database (WDOT 1998).
[d]Miles of airport runway per 1,000 square miles of land. Data from Wisconsin Airport Directory 2011–2012 web page (WDOT 2012).
[e]Data from Wisconsin Commercial Ports Association (WCPA 2010).

Hydroelectric. There are three hydroelectric power sites that generate 10 million kilowatt hours in the Northwest Sands Ecological Landscape. In the entire state, there are 68 sites, owned either by utility companies or privately owned sites, which generate a total of 1,462 million kilowatt hours (WDOA 2006).

Ethanol. The Northwest Sands counties produced only 3.2 million bushels of corn in 2002, or 0.5% of total production in the state (USDA NASS 2004). Acreage in agriculture made up 14% of the land base in 2002 (some woodland is counted as agriculture by this source) but had decreased by 20% between 1970 and 2002. There are no ethanol plants located in the Northwest Sands Ecological Landscape.

Wind. There are currently no sited or permitted industrial wind facilities in the Northwest Sands Ecological Landscape (WWIC 2014). Mean annual wind power densities are generally below 100 W/m^2 in this part of the state, indicating very limited potential for wind generation (USDE 2014).

Current Socioeconomic Conditions

The Northwest Sands counties have a low population density and an aging population. The population density of the four counties is about one-fifth that of the state as a whole. They have the second lowest percentage of young people under 18, the third highest proportion of elderly people over 65, and the second highest median age among the state ecological landscape county approximations. The percentage of minorities is below average, except for American Indians.

The economy of the Northwest Sands counties is depressed when compared with the rest of the state. Per capita income and average wage are third lowest, and the rates of poverty and unemployment are third and fifth highest, respectively, among the state's ecological landscape county approximations. The top four economic sectors in terms of employment within the Northwest Sands counties are Government, Tourism-related, Retail trade, and Health Care and Social Services.

Demography

Population Distribution

According to the U.S. Census Bureau, the 2010 population of the Northwest Sands counties was 90,541 (USCB 2012). Population centers include the cities of Superior (population 27,244) and Spooner (population 2,682). Superior is not within the ecological landscape but undoubtedly affects its economy by providing jobs for some of this ecological landscape's residents. Spooner is the only urban center (defined by the U.S. Census Bureau as cities with population over 2,500) within the ecological landscape. All other cities, towns, and villages in Northwest Sands counties have populations of less than 2,000 (USCB 2009).

Population Density

The population density of the Northwest Sands counties is about one-fifth that of the state as a whole, further defining this area's rural character. The population density is low, at 21 persons per square mile, in relation to the statewide population density of 105 persons per square mile (USCB 2012).

Population Structure

Age. The population in 2010 of the Northwest Sands counties was somewhat older than the state as a whole, with 18.1% of the population over 65, compared with 13.7% of the statewide population (USCB 2012). There was also a slightly lower percentage of people under 18, 20.6% of the population as compared with 23.6% statewide. The higher population percentage over age 65 suggests that the four counties tend to attract retirees.

Minorities. The area is racially homogeneous (as defined by U.S. Census Bureau reports) with a 92.4% white, non-Hispanic

population in 2010 (USCB 2012). That population is only 86.2% for the entire state. However, there is a significant percentage of American Indians in the four counties—ranging from 9.6% of the population in Bayfield County (note that the Red Cliff Chippewa Reservation is in Bayfield County but not in the Northwest Sands Ecological Landscape) to 1.2% of the population of Washburn County. Statewide, American Indians account for 1.0% of the population.

The tribal headquarters of the St. Croix band of Chippewa Indians is in Big Sand Lake, a Burnett County reservation community near the unincorporated village of Hertel. Reservation boundaries include about 3,000 acres of forested land and about 2,000 tribal people spread throughout Barron, Burnett, Polk, and Washburn counties in Wisconsin and in Pine County in east-central Minnesota (GLITC 2014). St. Croix Tribal Enterprises owns two casinos, St. Croix Casino in Turtle Lake, which employs more than 1,000 people, and the Hole in the Wall Casino and Hotel in Danbury, which employs more than 200 people.

Education. The Northwest Sands counties are comparable with the state in terms of percentage of residents 25 years old or older who have graduated from high school (90.1% in the Northwest Sands and 89.4% statewide) (USCB 2012). However, this area lags somewhat in attaining higher education; 21.1% of residents 25 or older have graduated from college or higher compared to 25.8% statewide.

Population Trends

While Wisconsin's overall population grew by more than 62% from 1950 to 2006, population in the Northwest Sands counties combined only grew by 11%, according to U.S. Census Bureau estimates (USCB 2009). The most populous Northwest Sands County is Douglas County, mostly because of the city of Superior, which is not in the Northwest Sands Ecological Landscape. Doublas County saw its population actually shrink by 6.3% from 1950 to 2006. Meanwhile, Burnett (59%) and Washburn (43%) counties saw population growth closer to that seen statewide over that period. Compared to statewide growth, population change in the Northwest Sands counties combined has been sporadic, as the effect of early to mid-century egress from failing settlements and farms has moderated, along with fluctuating transfer of seasonal homes to permanent residences. Only during the decade from 1970 to 1980 did Northwest Sands counties' combined population growth (9.9%) exceed that of the state (6.5%). Population growth has been flat during 2000–2010 (0.6% increase) (USCB 2012).

Housing

Housing density. The Northwest Sands counties' combined housing density in 2010 (14.6 housing units per square mile of land) is less than one-third of the state's housing density (48.5) (USCB 2012). Only the Superior Coastal Plain (11.9) and North Central Forest counties (12.4) have a combined lower housing density than the Northwest Sands counties. Housing density is slightly higher in Burnett (18.6 housing units per square mile of land), Douglas (17.5), and Washburn (16.3) counties and lowest in Bayfield County (8.8).

Seasonal Homes. In 2010, seasonal and recreational homes made up 28.6% of the Northwest Sands counties' housing stock, compared to only 6.3% statewide (USCB 2012). This indicates a high degree of tourism and part-time residents in this area. However, this trend is distributed unevenly through the counties—in Douglas County, only 8.8% of residences are seasonal or recreational, while in Burnett, Bayfield, and Washburn counties, 43.3%, 40.5%, and 35.1%, respectively, of residences are seasonal or recreational.

Housing Growth. Housing growth in Northwest Sands counties has generally kept pace with statewide housing growth since 1950 and been less volatile than population growth, thanks to the prevalence of seasonal homes in the region. From 2000 to 2007, housing growth in Northwest Sands counties (9.6%) was nearly equal to statewide growth (10.3%) (USCB 2009). The most rapid housing growth occurred between 1970 and 1980 when the number of houses in Northwest Sands counties grew by 35.2% (compared to 30.3% statewide), with Burnett County alone having 53.7% housing growth. Relatively high housing growth continued in Northwest Sands counties (18.2%) from 1980 to 1990, compared to statewide (14.9%). Among Northwest Sands counties, only Douglas County has consistently lagged behind statewide growth over time, likely because Douglas County has a much lower proportion of seasonal housing than its Northwest Sands neighbors.

Housing values. Housing values from 2005 to 2009, according to the U.S. Census Bureau, were low throughout the Northwest Sands counties compared to the statewide median ($166,100) (USCB 2012). Douglas County had the Northwest Sands counties' lowest median housing value ($124,000), while the remaining three Northwest Sands counties had housing values clustered between $148,000 in Washburn County and $159,200 in Bayfield County.

The Economy

Compared to the whole state, the Northwest Sands counties' economy is below statewide averages (Table 17.9). The considerable influence of the city of Superior, in Douglas County (which is not actually encompassed by the Northwest Sands Ecological Landscape), may cause some county-wide numbers to be misleading in terms of the Northwest Sands counties.

Income

Per Capita Income. Total personal income for the four Northwest Sands counties in 2006 was $2.4 billion (only 1.3% of the state total). Because Douglas County contributes nearly half of the total personal income ($1.16 billion), and much

of that income comes from the Superior area, we can assume that the Northwest Sands counties has an even smaller portion of statewide income. Per capita income in Northwest Sands counties ($26,208) in 2006 was lower than the statewide average of $34,405 and was the lowest among any of Wisconsin's 16 ecological landscape county approximations (Table 17.9). However, per capita income has been increasing for the Northwest Sands counties. When adjusted for inflation (year 2000 dollars), the per capita income was $13,011 in 1970, $17,638 in 1980, $17,485 in 1990, and $20,582 in 1999 (USDC BEA 2006).

Household Income. Median household income was lower in each of the four Northwest Sands counties when compared to the 2005 statewide average of $47,141 (USCB 2009). U.S. Census Bureau estimates of median household income in the Northwest Sands Ecological Landscape range from $40,984 in Bayfield County to $38,895 in Burnett County.

Earnings Per Job. In 2006 average earnings per job for Northwest Sands counties ($28,113) were considerably lower than the statewide average ($36,142) (USDC BEA 2006). Earnings per job numbers vary widely within Northwest Sands counties: Bayfield County was lowest with an average wage of $22,403 per job while Douglas County was highest with $31,072 per job (Table 17.9). Presumably, the presence of higher paying jobs in Superior (Douglas County) has inflated this figure so that the actual earnings per job within the Northwest Sands counties may be overstated here. Since 1970 real wages have remained about the same in the four counties. In 1970 the average wage was $21,861; in 1980 it was $22,869; in 1990 it was $20,311; and in 1999 it was $21,708 (adjusted for inflation, year 2000 dollars).

Unemployment

The Northwest Sands counties each had higher unemployment rates than the statewide average of 4.7% in 2006 (USDL BLS 2006; Table 17.9). Combined, the Northwest Sands counties had an unemployment rate of 5.7%. Douglas County was lowest (5.0%), while unemployment rates in Washburn (6.6%), Bayfield (6.4%), and Burnett (5.8%) were significantly higher than the state average. Unemployment rates became much higher after 2008 throughout the state but have become lower again.

Poverty

Poverty Rates. The U.S. Census Bureau estimated the Northwest Sands counties' 2005 poverty rate for all residents at 11.7%, slightly higher than the state average of 10.2% (Table 17.9). Douglas County generally is better off economically than the other three counties due to its proximity to the Duluth-Superior metropolitan area. However, characteristic of urban centers the percentage of people living in poverty in Douglas County (12.4%) is actually higher than in other Northwest Sands counties.

Child Poverty Rates. Child poverty rates are consistently higher in the Northwest Sands counties than in Wisconsin as a whole. According to U.S. Census Bureau estimates, poverty rates for children under 18 ranged from 17.4% in Washburn County to 18.6% in Burnett County, compared to Wisconsin's childhood poverty rate of 14% (USCB 2009).

Residential Property Values

Overall, residential property values in the Northwest Sands counties ($138,506 per housing unit) are very similar to the statewide average ($134,021) (Table 17.10). However, Douglas County, with property value per housing unit of $100,809, was markedly lower than the remaining Northwest Sands counties, again attributable to the impact of the Superior area. Overall, home values in Northwest Sands counties were much higher than the statewide average and contrast with the otherwise deflated economic numbers for the area. Housing values in northern Wisconsin tend to be high due to the prevalence of vacation and second homes, as appears to be the case in Northwest Sands counties.

Important Economic Sectors

The 39,535 jobs in the Northwest Sands counties represented only 1.1% of total employment in Wisconsin in 2007 (Table 17.11; MIG 2009). The top four economic sectors in terms of the number of jobs provided to the local economy

Table 17.9. *Economic indicators for the Northwest Sands counties and Wisconsin.*

	Per capita income[a]	Average earnings per job[a]	Unemployment rate[b]	Poverty rate[c]
Wisconsin	**$34,405**	**$36,142**	**4.7%**	**10.2%**
Bayfield	$27,066	$22,403	6.4%	11.2%
Burnett	$26,051	$25,615	5.8%	11.7%
Douglas	$26,396	$31,072	5.0%	12.4%
Washburn	$25,095	$25,881	6.6%	11.3%
Northwest Sands counties	**$26,208**	**$28,113**	**5.7%**	**11.7%**

[a]U.S. Bureau of Economic Analysis, 2006 figures.
[b]U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics, 2006 figures.
[c]U.S. Bureau of the Census, Small Area Income and Poverty Estimates, 2005 figures.

in the Northwest Sands counties are Government (18.7% of Northwest Sands counties' employment), Tourism-related (15.8%), Retail Trade (10.7%), and Health Care and Social Services (9.7%). Service sector jobs have come to dominate the economy in the Northwest Sands counties with only about 20% of jobs being in Manufacturing, Transportation and Warehousing, and Construction combined. Figures for Agriculture, Fishing, and Hunting (4.0% of employment in Northwest Sands counties) and Forest Products and Processing (2.7%) are only slightly higher than statewide averages and do not greatly contribute to Northwest Sands counties' employment. For definitions of economic sectors, see the U.S. Census Bureau's North American Industry Classification System web page (USCB 2015).

Northwest Sands counties have high levels of service jobs with low wages and few benefits, a high proportion of part-time and seasonal jobs, a narrow economic activity base with high reliance on the volatile recreation sector, and low representation of important agriculture, manufacturing, and technology sector jobs in the Northwest Sands counties. This contributes to high unemployment, low per capita income, and generalized economic stress.

Importance of economic sectors within the Northwest Sands counties when compared to the rest of the state was evaluated using an economic base analysis to yield a standard metric called a location quotient (Quintero 2007). Economic base analysis compares the percentage of all jobs in an ecological landscape county approximation for a given economic

Table 17.10. *Property values for the Northwest Sands counties and Wisconsin, assessed in 2006 and collected in 2007.*

	Residential property value	Housing units	Residential property value per housing unit
Wisconsin	**$340,217,559,700**	**2,538,538**	**$134,021**
Bayfield	$1,941,013,500	12,950	$149,885
Burnett	$2,275,429,400	13,747	$165,522
Douglas	$2,157,611,600	21,403	$100,809
Washburn	$1,963,992,500	12,100	$162,313
Northwest Sands counties	**$8,338,047,000**	**60,200**	**$138,506**

Sources: Wisconsin Department of Revenue 2006–2007 property tax master file (except housing units); housing units: U. S. Census Bureau estimates for July 1, 2006.

Table 17.11. *Total and percentage of jobs in 2007 in each economic sector within the Northwest Sands (NWS) counties. The economic sectors providing the highest percentage of jobs in the Northwest Sands counties are highlighted in blue.*

Industry sector	WI employment	% of WI total	NWS counties employment	% of NWS counties total
Agriculture, Fishing & Hunting	110,408	3.1%	1,582	4.0%
Forest Products & Processing	88,089	2.5%	1,049	2.7%
Mining	3,780	0.1%	14	0.0%
Utilities	11,182	0.3%	219	0.6%
Construction	200,794	5.6%	2,550	6.5%
Manufacturing (non-wood)	417,139	11.7%	2,739	6.9%
Wholesale Trade	131,751	3.7%	1,062	2.7%
Retail Trade	320,954	9.0%	4,247	10.7%
Tourism-related	399,054	11.2%	6,250	15.8%
Transportation & Warehousing	108,919	3.1%	2,607	6.6%
Information	57,081	1.6%	311	0.8%
Finance & Insurance	168,412	4.7%	863	2.2%
Real Estate, Rental & Leasing	106,215	3.0%	593	1.5%
Pro, Science & Tech Services	166,353	4.7%	864	2.2%
Management	43,009	1.2%	223	0.6%
Admin, Support, Waste, & Remediation	166,405	4.7%	789	2.0%
Private Education	57,373	1.6%	75	0.2%
Health Care & Social Services	379,538	10.7%	3,828	9.7%
Other Services	187,939	5.3%	2,285	5.8%
Government	430,767	12.1%	7,385	18.7%
Totals	**3,555,161**		**39,535**	

Source: IMPLAN, © MIG, Inc. 2009 (MIG 2009).

sector to the percentage of all jobs in the state for the same economic sector. For example, if 10% of the jobs within an ecological landscape county approximation are in the manufacturing sector and 10% of all jobs in the state are in the Manufacturing sector, then the quotient would be 1.0, indicating that this ecological landscape county approximation contributes jobs to the Manufacturing sector at the same rate as the statewide average. If the quotient is greater than 1.0, the ecological landscape county approximation is contributing more jobs to the sector than the state average. If the quotient is less than 1.0, the ecological landscape county approximation is contributing fewer jobs to the sector than the state average.

When compared with the rest of the state, the Northwest Sands counties combined had nine sectors with quotients higher than 1.0 (Figure 17.18). The Transportation and Warehousing sector stands out in the Northwest Sands counties as providing a percentage of jobs higher than the state average. Other economic sectors providing a percentage of jobs higher than the state average, listed in order of their relative importance are Utilities; Government; Tourism-related; Agriculture, Fishing, and Hunting; Retail Trade; Construction; Other Services; and Forest Products and Processing (see Appendix 17.I at the end of this chapter).

The Other Services sector consists primarily of equipment and machinery repairing, promoting or administering religious activities, grant making, advocacy, and providing dry-cleaning and laundry services, personal care services, death care services, pet care services, photo finishing services, and temporary parking services. The Tourism-related sector includes relevant subsectors within Retail Trade, Passenger Transportation, and Arts, Entertainment, and Recreation (Marcouiller and Xia 2008). The Tourism-related sector also includes all Accommodation and Food Services. The Forest Products and Processing sector includes sectors in logging, pulp and paper manufacturing, primary wood manufacturing (e.g., sawmills), and secondary wood manufacturing (e.g., furniture manufacturing).

Urban Influence

The U.S. Department of Agriculture's Economic Research Service (USDA ERS) divides counties into 12 groups on a continuum of urban influence, with 1 representing large metropolitan areas, 2 representing smaller metropolitan areas, and the remaining classes from 3 to 12 representing nonmetropolitan counties increasingly less populated and isolated from urban influence (USDA ERS 2012b). The concept of urban influence assumes population size, urbanization, and access to larger adjacent economies are crucial elements in evaluating potential of local economies. Douglas County is classified as a smaller metropolitan area (class 2), due to the Duluth/Superior area, which actually lies north of the Northwest Sands counties' boundary. The remaining Northwest Sands counties are nonmetropolitan (rural) with moderate degrees of "influence" from adjacent urban areas. Burnett County (class 4) is next most urban influenced, followed by Washburn (class 6) and Bayfield (class 7) counties.

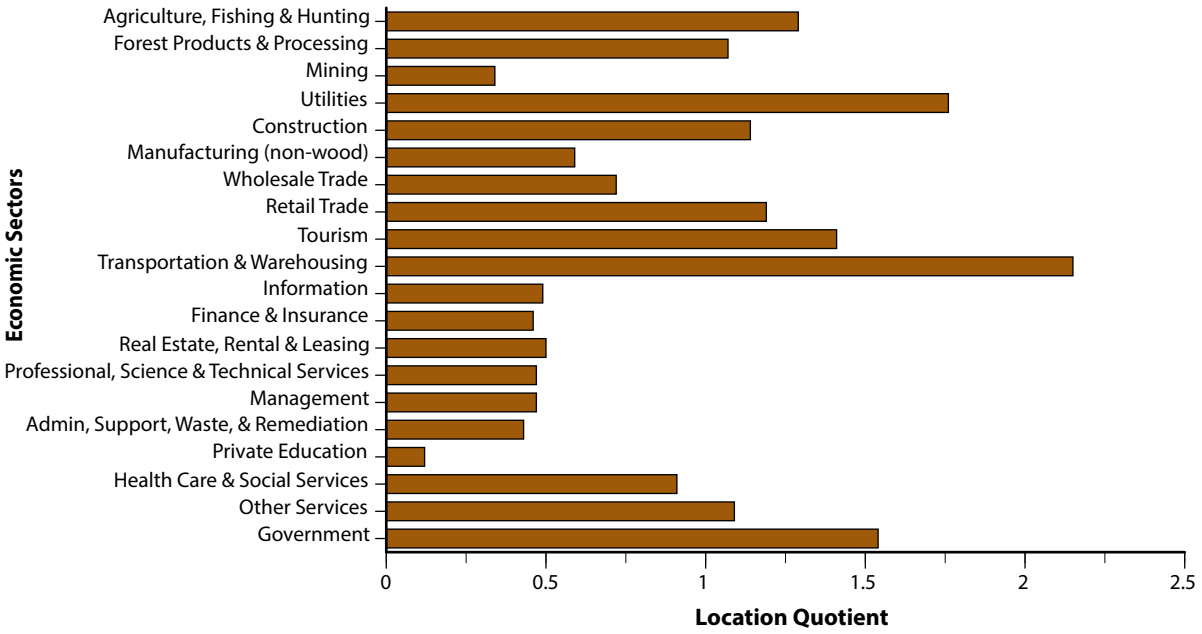


Figure 17.18. *Importance of economic sectors within the Northwest Sands counties when compared to the rest of the state. If the location quotient is greater than 1.0, the Northwest Sands counties are contributing more jobs to that economic sector than the state average. If the location quotient is less than 1.0, the Northwest Sands counties are contributing fewer jobs to that economic sector than the state average.*

Economic Types

The USDA ERS classifies counties in one of six mutually exclusive categories: farming-dependent counties, mining-dependent counties, manufacturing-dependent counties, government-dependent counties, service-dependent counties, and nonspecialized counties (USDA ERS 2012a). Burnett County was classified as manufacturing-dependent in 2004, according to USDA ERS economic specialization definitions. Bayfield, Douglas, and Washburn counties were all classified as nonspecialized.

Policy Types

The USDA Economic Research Service also classifies counties according to "policy types" deemed especially relevant to rural development policy (USDA ERS 2012a). Bayfield, Burnett, and Washburn counties were classified as "nonmetro recreation" counties, which are rural counties classified using a combination of factors, including share of employment or share of earnings in recreation-related industries in 1999, share of seasonal or occasional use housing units in 2000, and per capita receipts from motels and hotels in 1997, indicating economic dependence especially upon an influx of tourism and recreational dollars. Burnett and Washburn counties were also classified as "retirement destination" counties, those counties in which the number of residents 60 years of age and older grew by 15% or more between 1990 and 2000 due to in-migration. These counties are shaped by an influx of an aging population and have particular needs for health care and services specific to that population.

Integrated Opportunities for Management

Use of natural resources for human needs within the constraints of sustainable ecosystems is an integral part of ecosystem management. Integrating ecological management with socioeconomic programs or activities can result in efficiencies in land use, tax revenues, and private capital. This integration can also help generate broader and deeper support for sustainable ecosystem management. However, any human modification or use of natural communities has trade-offs that benefit some species and other natural features and harm others. Even relatively benign activities such as ecotourism will have impacts on the ecology of an area. Trade-offs caused by management actions need to be carefully weighed when planning management to ensure that some species are not being irreparably harmed. Maintaining healthy, sustainable ecosystems provides many benefits to people and our economy. The development of ecologically sound management plans should save money and sustain natural resources in the long run.

The principles of integrating natural resources and socioeconomic activities are similar across the state. A discussion of "Integrated Ecological and Socioeconomic Opportunities" can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management." That section offers suggestions on how and when ecological and socioeconomic needs might be integrated and gives examples of the types of activities that might work together when planning the management of natural resources within a given area.

Appendices

Appendix 17.A. *Watershed water quality summary for the Northwest Sands Ecological Landscape.*

Watershed no.	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Very Poor/Poor/Fair/Good/Very Good/Excellent)
LC10	Brill and Red Cedar rivers[b]	190,518	Very Good; turbidity far d.s.
LS03	Amnicon and Middle rivers[b]	184,908	Good; some clay turbidity, habitat loss and excess plant growth; past - fecal coliform
LS04	Bois Brule River	127,773	Very Good to Excellent; many springs; numerous ORWs
LS05	Iron River	136,568	Very Good; several ORWs; needs streambank protection?
LS06	Bayfield Peninsula NW	151,070	Good to Excellent; ORWs; ERWs; logging; stormwater episodes with heavy clay suspension and deposition
LS07	Bayfield Peninsula SE	192,951	Good to Excellent; ORWs; some silvicultural erosion
LS08	Fish Creek	100,194	Very Good; sand barrens groundwater feeds streams
LS10	White River	234,338	Very Good to Excellent; a few ORW/ERW; some stream habitat damage and spring siltation; NPS (septic leaks)
SC09	Wolf Creek	70,515	Good to Very Good; temp; sed; several eutrophic lakes
SC10	Trade River	124,754	God to Very Good; sed; NPS; beaver dams; some lakes slightly eutrophic
SC11	Wood River	140,951	Very Good; some mesotrophic lakes and some turbid; stream habit damage and beaver dams
SC12	Clam River	132,393	Very Good; a few lakes moderately eutrophic; stream beaver dams, temp and habitat damage
SC13	North Fork Clam River	111,045	Excellent; lake trophic status good; stream temp & habitat
SC14	Lower Yellow River	133,726	Very Good; lakes – good trophic health; streams meet potential
SC15	Shell Lake, Upper Yellow River	106,666	Very Good to Excellent; lakes – good trophic status; elevated temps and modified habitat
SC16	Upper Tamarack	98,924	Very Good to Excellent; Radigan Flowage has winterkill
SC17	St. Croix and Moose Rivers	126,257	Very Good to Excellent; beaver dams and hab
SC18	Upper St. Croix, Eau Claire rivers[b]	177,851	Very Good to Excellent; lakes mesotrophic; some Hg
SC19	Lower Namekagon	153,176	Very Good to Excellent ; Stream temp, habitat damage, and beaver dams; mesotrophic seepage lakes
SC20	Totagatic River	211,156	Excellent; most lakes oligotrophic to mesotrophic
SC21	Trego Lake/Middle Namekagon River	172,088	Very Good; streambank pasturing, dams and habitat damage; lakes slightly eutrophic; some winterkill
SC22	Upper Namekagon River	126,592	Excellent; beaver dams, stream habitat damage; mesotrophic lakes
UC20	Couderay River[b]	135,838	Excellent; sturgeon obstruction; lakes slightly eutrophic

Source: Wisconsin DNR Bureau of Watershed data.

[a]Based on Wisconsin DNR watershed water quality reports.

[b]Only a small fraction of this watershed lies within this ecological landscape, so overall impacts of land uses within the landscape are unlikely to impact water quality within the watershed to any appreciable degree.

Abbreviations:

d.s. = Downstream of this ecological landscape.
ERW = Exceptional Resource Water (very good to excellent water quality, with point source discharges).
Hab = Stream habitat damage.
Hg = Mercury contamination of fish, mainly deposited by coal combustion, or sometimes by industry.
ORW = Outstanding Resource Water (very good to excellent water quality, with no point source discharges).
NPS = Nonpoint source pollutants, such as farm or parking lot runoff, or septic system leakage.
Sed = Excess sedimentation.
Temp = Elevated temperatures in some stream reaches.
> = Yields, creates or results in (the listed impacts).

Appendix 17.B. *Forest habitat types in the Northwest Sands Ecological Landscape.*

The forest habitat type classification system (FHTCS) is a site classification system based on the floristic composition of plant communities. The system depends on the identification of potential climax associations, repeatable patterns in the composition of the understory vegetation, and differential understory species. It groups land units with similar capacity to produce vegetation. The floristic composition of the plant community is used as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and community development. This classification system enables the recognition and classification of ecologically similar landscape units (site types) and forest plant communities (vegetation associations).

A forest habitat type is an aggregation of sites (units of land) capable of producing similar late-successional (potential climax) forest plant communities. Each recognizable habitat type represents a relatively narrow segment of environmental variation that is characterized by a certain limited potential for vegetation development. Although at any given time, a habitat type can support a variety of disturbance-induced (seral) plant communities, the ultimate product of succession is presumed to be a similar climax community. Field identification of a habitat type provides a convenient label (habitat type name) for a given site, and places that site in the context of a larger group of sites that share similar ecological traits. Forest habitat type groups more broadly combine individual habitat types that have similar ecological potentials.

Individual forest cover types classify current overstory vegetation, but these associations usually encompass a wide range of environmental conditions. In contrast, individual habitat types group ecologically similar sites in terms of vegetation potentials. Management interpretations can be refined and made significantly more accurate by evaluating a stand in terms of the current cover type (current dominant vegetation) plus the habitat type (potential vegetation).

Habitat types	Description of forest habitat types found in the Northwest Sands Ecological Landscape
ACl	*Acer saccharum-Clintonia borealis* Sugar maple-yellow beadlily
ArAbVCo	*Acer rubrum-Abies balsamea/Vaccinium angustifolium-Cornus canadensis* Red maple-balsam fir/blueberry-bunchberry
ArVRp	*Acer rubrum/Vaccinium angustifolium-Rubus pubescens* Red maple/blueberry-dwarf raspberry
ASnMi	*Acer saccharum/Sanicula marilandica-Mitchella repens* Sugar maple/black snakeroot-partridgeberry
AVCl	*Acer saccharum/Vaccinium angustifolium-Clintonia borealis* Sugar maple/blueberry-yellow beadlily
AVDe	*Acer saccharum/Vaccinium angustifolium-Desmodium glutinosum* Sugar maple/blueberry-pointed-leaved tick trefoil
PArVAa-Po	*Pinus strobus-Acer rubrum/Vaccinium angustifolium-Aralia nudicaulis, Polygonatum pubescens* variant White pine-red maple/blueberry-wild sarsaparilla, hairy Solomon's seal variant
PArVAm	*Pinus strobus-Acer rubrum/Vaccinium angustifolium-Amphicarpa bracteata* White pine-red maple/blueberry-hog peanut
PArV-U	*Pinus strobus-Acer rubrum/Vaccinium angustifolium, Uvularia sessilifolia* variant White pine-red maple/blueberry, sessile bellwort variant
PQG	*Pinus strobus-Quercus* spp./*Gaultheria procumbens* White pine-pin oak/wintergreen
PQGCe	*Pinus strobus-Quercus* spp./*Gaultheria procumbens-Ceanothus americanus* White pine-pin oak/wintergreen-New Jersey tea
Qap	*Quercus* spp./*Amorpha canescens* Oak/leadplant

Source: Kotar et al. (2002).

Appendix 17.C. *The Natural Heritage Inventory (NHI) table of rare species and natural community occurrences (plus a few miscellaneous features tracked by the NHI program) for the Northwest Sands (NWS) Ecological Landscape in November 2009. See the Wisconsin Natural Heritage Working List online for the current status (http://dnr.wi.gov, keyword "NHI").*

Scientific name (common name)	Lastobs Date	EOs[a] in NWS	EOs in WI	Percent in NWS	State rank	Global rank	State status	Federal status
MAMMALS								
Canis lupus (gray wolf)	2008	32	204	16%	S2	G4	SC/FL	LE
Napaeozapus insignis (woodland jumping mouse)	1997	1	15	7%	S2S3	G5	SC/N	
Sorex hoyi (pygmy shrew)	1997	3	39	8%	S3S4	G5	SC/N	
Spermophilus franklinii (Franklin's ground squirrel)	1983	1	12	8%	S2	G5	SC/N	
BIRDS[b]								
Accipiter gentilis (Northern Goshawk)	2005	9	141	6%	S2B,S2N	G5	SC/M	
Ammodramus leconteii (Le Conte's Sparrow)	2003	2	22	9%	S2S3B	G4	SC/M	
Ammodramus nelsoni (Nelson's Sparrow)	2004	4	6	67%	S1B	G5	SC/M	
Asio otus (Long-eared Owl)	2003	1	8	13%	S2B	G5	SC/M	
Bartramia longicauda (Upland Sandpiper)	2009	4	54	7%	S2B	G5	SC/M	
Botaurus lentiginosus (American Bittern)	2007	4	41	10%	S3B	G4	SC/M	
Bucephala clangula (Common Goldeneye)	2006	1	5	20%	S2B	G5	SC/M	
Buteo lineatus (Red-shouldered Hawk)	2008	7	301	2%	S3S4B,S1N	G5	THR	
Chlidonias niger (Black Tern)	2008	3	60	5%	S2B	G4	SC/M	
Coccyzus americanus (Yellow-billed Cuckoo)	2008	3	39	8%	S3B	G5	SC/M	
Coturnicops noveboracensis (Yellow Rail)	2005	5	22	23%	S1B	G4	THR	
Cygnus buccinator (Trumpeter Swan)	1999	5	22	23%	S4B	G4	SC/M	
Dendroica kirtlandii (Kirtland's Warbler)[c, d]	1989	4	11	36%	S1	G1	SC/FL	LE
Dendroica tigrina (Cape May Warbler)[c]	1997	3	26	12%	S3B	G5	SC/M	
Falcipennis canadensis (Spruce Grouse)	1990	2	33	6%	S1S2B,S1S2N	G5	THR	
Haliaeetus leucocephalus (Bald Eagle)	2008	128	1286	10%	S4B,S2N	G5	SC/P	
Ixobrychus exilis (Least Bittern)	1989	1	23	4%	S3B	G5	SC/M	
Oporornis agilis (Connecticut Warbler)	2006	6	27	22%	S2S3B	G4	SC/M	
Pandion haliaetus (Osprey)	2005	63	733	9%	S4B	G5	SC/M	
Phalaropus tricolor (Wilson's Phalarope)	2002	2	4	50%	S1B	G5	SC/M	
Picoides arcticus (Black-backed Woodpecker)	1999	1	17	6%	S2B	G5	SC/M	
Podiceps grisegena (Red-necked Grebe)	2003	2	13	15%	S1B	G5	END	
Protonotaria citrea (Prothonotary Warbler)	2007	1	40	3%	S3B	G5	SC/M	
Seiurus motacilla (Louisiana Waterthrush)[c]	2007	1	34	3%	S3B	G5	SC/M	
Tympanuchus cupido (Greater Prairie-chicken)	1979	2	60	3%	S1B,S2N	G4	THR	
Tympanuchus phasianellus (Sharp-tailed Grouse)	2009	3	7	43%	S1B,S2N	G4	SC/H	
Wilsonia canadensis (Canada Warbler)[c]	2009	4	20	20%	S3B	G5	SC/M	
Wilsonia citrina (Hooded Warbler)[c]	2008	2	32	6%	S2S3B	G5	THR	
HERPTILES								
Emydoidea blandingii (Blanding's turtle)	2008	22	316	7%	S3	G4	THR	
Glyptemys insculpta (wood turtle)	2007	9	262	3%	S2	G4	THR	
Heterodon platirhinos (eastern hog-nosed snake)	2009	1	6	17%	S3?	G5	SC/H	
Lithobates catesbeianus (American bullfrog)	1997	3	70	4%	S3	G5	SC/H	
Lithobates septentrionalis (mink frog)	2006	3	7	43%	S3S4	G5	SC/H	
Pituophis catenifer (gophersnake)	1983	1	29	3%	S2S3	G5	SC/P	
Plestiodon septentrionalis (prairie skink)	2009	2	2	100%	S3	G5	SC/H	
FISHES								
Acipenser fulvescens (lake sturgeon)	1991	8	99	8%	S3	G3G4	SC/H	
Etheostoma microperca (least darter)	1987	7	83	8%	S3	G5	SC/N	

Continued on next page

Appendix 17.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NWS	EOs in WI	Percent in NWS	State rank	Global rank	State status	Federal status
Fundulus diaphanus (banded killifish)	1983	12	105	11%	S3	G5	SC/N	
Moxostoma valenciennesi (greater redhorse)	1993	8	56	14%	S3	G4	THR	
Notropis anogenus (pugnose shiner)	1983	10	49	20%	S2	G3	THR	
Percina evides (gilt darter)	1977	6	26	23%	S2	G4	THR	
MUSSELS/CLAMS								
Alasmidonta marginata (elktoe)	1997	3	44	7%	S4	G4	SC/P	
Cyclonaias tuberculata (purple wartyback)	1997	2	16	13%	S1S2	G5	END	
Elliptio complanata (eastern elliptio)	1987	1	2	50%	S3	G5	SC/P	
Pleurobema sintoxia (round pigtoe)	1997	3	50	6%	S3	G4G5	SC/P	
BUTTERFLIES/MOTHS								
Atrytonopsis hianna (dusted skipper)	1999	7	31	23%	S3	G4G5	SC/N	
Boloria eunomia (bog fritillary)	2004	10	49	20%	S3	G5	SC/N	
Callophrys henrici (Henry's elfin)	1994	6	19	32%	S1S2	G5	SC/N	
Catocala whitneyi (Whitney's underwing moth)	1999	1	10	10%	S3	G3G4	SC/N	
Chlosyne gorgone (gorgone checker spot)	1988	1	40	3%	S3	G5	SC/N	
Erynnis martialis (mottled dusky wing)	1996	5	10	50%	S2	G3	SC/N	
Hemileuca sp. 3 (midwestern fen buckmoth)	1980	1	10	10%	S3	G5T3T4	SC/N	
Hesperia comma (laurentian skipper)	1989	1	15	7%	S3	G5	SC/N	
Hesperia leonardus (Leonard's skipper)	1999	3	29	10%	S3	G4	SC/N	
Hesperia metea (cobweb skipper)	1996	2	12	17%	S2	G4G5	SC/N	
Lycaeides melissa samuelis (Karner blue)	2004	37	316	12%	S3	G5T2	SC/FL	LE
Oeneis chryxus (chryxus arctic)	2007	8	9	89%	S2?	G5	SC/N	
Papaipema beeriana (Liatris borer moth)	1997	1	11	9%	S2	G2G3	SC/N	
Phyciodes batesii lakota (Lakota crescent)	1996	3	24	13%	S3	G4T4	SC/N	
Poanes viator (broad-winged skipper)	1995	1	36	3%	S3	G5	SC/N	
Psectraglaea carnosa (pink sallow)	1996	1	2	50%	S2	G3	SC/N	
Schinia indiana (phlox moth)	1994	2	31	6%	S2S3	G2G4	END	
DRAGONFLIES/DAMSELFLIES								
Aeshna eremita (lake darner)	2002	1	15	7%	S3	G5	SC/N	
Gomphus graslinellus (pronghorned clubtail)	1996	2	5	40%	S2	G5	SC/N	
Nannothemis bella (elfin skimmer)	1995	2	12	17%	S2S3	G4	SC/N	
Ophiogomphus anomalus (extra-striped snaketail)	1994	1	14	7%	S3	G4	END	
Ophiogomphus howei (pygmy snaketail)	1999	3	33	9%	S4	G3	THR	
Ophiogomphus smithi (sand snaketail)	1990s	3	28	11%	S2	G2G3	SC/N	
Somatochlora forcipata (forcipate emerald)	1996	2	10	20%	S2	G5	SC/N	
BEETLES								
Agabus bicolor (a predaceous diving beetle)	2004	2	9	22%	S3	GNR	SC/N	
Cicindela longilabris (a tiger beetle)	2004	1	6	17%	S2S3	G5	SC/N	
Cicindela patruela patruela (a tiger beetle)	2004	8	26	31%	S2	G3T3	SC/N	
Cymbiodyta acuminata (a water scavenger beetle)	1996	1	7	14%	S3	GNR	SC/N	
Cymbiodyta minima (a water scavenger beetle)	1996	1	3	33%	S3	GNR	SC/N	
Haliplus canadensis (a crawling water beetle)	1996	1	2	50%	S2	GNR	SC/N	
Haliplus pantherinus (a crawling water beetle)	1996	2	13	15%	S2S3	GNR	SC/N	
Hydroporus badiellus (a predaceous diving beetle)	1996	2	7	29%	S3?	GNR	SC/N	
Hydroporus pseudovilis (a predaceous diving beetle)	1996	1	4	25%	S1S2	GNR	SC/N	
Hydroporus vittatus (a predaceous diving beetle)	1996	1	17	6%	S3	GNR	SC/N	

Continued on next page

Appendix 17.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NWS	EOs in WI	Percent in NWS	State rank	Global rank	State status	Federal status
Hygrotus sylvanus (sylvan hygrotus diving beetle)	1991	1	3	33%	S1	GU	SC/N	
MISCELLANEOUS INSECTS/SPIDERS								
Aeropedellus clavatus (club-horned grasshopper)	2006	1	3	33%	S2	G5	SC/N	
Chloealtis abdominalis (Rocky Mountain sprinkled locust)	2005	2	7	29%	S2?	G5	SC/N	
Fitchiella robertsoni (an issid planthopper)	2006	1	1	100%	S1?	GNR	SC/N	
Lepidostoma libum (a lepidostomatid caddisfly)	1996	1	5	20%	S1?	G3G4	SC/N	
Orphulella pelidna (spotted-winged grasshopper)	2004	1	7	14%	S2S3	G5	SC/N	
PLANTS								
Arabis missouriensis var. *deamii* (Deam's rockcress)	1984	1	22	5%	S2	G5?QT3?Q	SC	
Arethusa bulbosa (swamp-pink)	1996	5	96	5%	S3	G4	SC	
Asclepias ovalifolia (dwarf milkweed)	2007	18	60	30%	S3	G5?	THR	
Botrychium pallidum (pale moonwort)	2008	1	1	100%	S1	G3	SC	
Botrychium rugulosum (rugulose grape-fern)	2008	2	7	29%	S2	G3	SC	
Calamagrostis stricta (slim-stem small-reedgrass)	2008	4	34	12%	S3	G5	SC	
Callitriche hermaphroditica (autumnal water-starwort)	1996	3	11	27%	S2	G5	SC	
Calypso bulbosa (fairy slipper)	1996	4	34	12%	S3	G5	THR	
Carex assiniboinensis (Assiniboine sedge)	2007	2	33	6%	S3	G4G5	SC	
Carex michauxiana (Michaux sedge)	2008	2	8	25%	S2	G5	THR	
Carex prasina (drooping sedge)	1993	1	31	3%	S3	G4	THR	
Carex richardsonii (Richardson sedge)	1996	6	24	25%	S2	G4	SC	
Carex tenuiflora (sparse-flowered sedge)	2007	4	84	5%	S3	G5	SC	
Carex vaginata (sheathed sedge)	2006	12	35	34%	S3	G5	SC	
Cirsium flodmanii (Flodman thistle)	1996	1	2	50%	S1	G5	SC	
Clematis occidentalis (purple clematis)	1996	1	32	3%	S3	G5	SC	
Cypripedium arietinum (ram's-head lady's-slipper)	2006	1	21	5%	S2	G3	THR	
Cypripedium parviflorum var. *makasin* (northern yellow lady's-slipper)	2008	11	78	14%	S3	G5T4Q	SC	
Cypripedium reginae (showy lady's-slipper)	2007	4	99	4%	S3	G4	SC	
Dalea villosa var. *villosa* (silky prairie-clover)	2008	12	18	67%	S2	G5	SC	
Deschampsia flexuosa (crinkled hairgrass)	2002	15	44	34%	S3	G5	SC	
Epilobium palustre (marsh willow-herb)	2005	9	37	24%	S3	G5	SC	
Equisetum palustre (marsh horsetail)	2001	1	21	5%	S2	G5	SC	
Eriophorum alpinum (alpine cotton-grass)	1996	1	25	4%	S2	G5	SC	
Eriophorum chamissonis (russet cotton-grass)	1996	1	6	17%	S2	G5	SC	
Huperzia selago (fir clubmoss)	1996	1	7	14%	S2	G5	SC	
Leucophysalis grandiflora (large-flowered ground-cherry)	1992	1	3	33%	S1	G4?	SC	
Liatris punctata var. *nebraskana* (dotted blazing star)	1989	2	20	10%	S2S3	G5T3T5	END	
Malaxis monophyllos var. *brachypoda* (white adder's-mouth)	2005	1	48	2%	S3	G4Q	SC	
Myriophyllum farwellii (Farwell's water-milfoil)	1971	1	60	2%	S3	G5	SC	
Parnassia palustris (marsh grass-of-parnassus)	1996	1	7	14%	S2	G5	THR	
Petasites sagittatus (arrow-leaved sweet-coltsfoot)	1996	1	31	3%	S3	G5	THR	
Platanthera hookeri (Hooker's orchid)	2001	3	20	15%	S2S3	G4	SC	
Platanthera orbiculata (large roundleaf orchid)	2002	21	78	27%	S3	G5	SC	
Poa paludigena (bog bluegrass)	2007	6	41	15%	S3	G3	THR	
Pyrola minor (lesser wintergreen)	1996	1	3	33%	S1	G5	END	
Ranunculus lapponicus (Lapland buttercup)	1996	2	2	100%	S1	G5	END	
Rhynchospora fusca (brown beakrush)	1996	1	21	5%	S2	G4G5	SC	

Continued on next page

Appendix 17.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NWS	EOs in WI	Percent in NWS	State rank	Global rank	State status	Federal status
Ribes hudsonianum (northern black currant)	2006	9	76	12%	S3	G5	SC	
Scirpus torreyi (Torrey's bulrush)	2000	2	21	10%	S2	G5?	SC	
Senecio congestus (marsh ragwort)	2009	1	3	33%	S1	G5	SC	
Sparganium glomeratum (northern bur-reed)	2001	1	19	5%	S2	G4?	THR	
Talinum rugospermum (prairie fame-flower)	1994	2	54	4%	S3	G3G4	SC	
Triglochin maritima (common bog arrow-grass)	2004	1	59	2%	S3	G5	SC	
Utricularia purpurea (purple bladderwort)	2006	1	55	2%	S3	G5	SC	
Viola fimbriatula (sand violet)	1981	2	17	12%	S2	G5T5	END	
COMMUNITIES								
Alder Thicket	1997	5	106	5%	S4	G4	NA	
Emergent Marsh	1980	1	272	0%	S4	G4	NA	
Forested Seep	2008	1	15	7%	S2	GNR	NA	
Great Lakes Beach	1980	1	24	4%	S2	G3	NA	
Hardwood Swamp	2007	5	53	9%	S3	G4	NA	
Inland Beach	2003	4	17	24%	S3	G4G5	NA	
Lake—Deep, Soft, Seepage	2005	3	49	6%	S3	GNR	NA	
Lake—Hard Bog	1981	1	18	6%	S2	GNR	NA	
Lake—Shallow, Hard, Drainage	1980	1	35	3%	SU	GNR	NA	
Lake—Shallow, Hard, Seepage	1979	1	52	2%	SU	GNR	NA	
Lake—Shallow, Soft, Drainage	1980	1	36	3%	S3	GNR	NA	
Lake—Shallow, Soft, Seepage	2003	10	87	11%	S4	GNR	NA	
Lake—Soft Bog	1980	2	52	4%	S4	GNR	NA	
Muskeg	2004	1	45	2%	S4	G4G5	NA	
Northern Dry Forest	2008	13	63	21%	S3	G3?	NA	
Northern Dry-mesic Forest	2007	12	284	4%	S3	G4	NA	
Northern Mesic Forest	1996	2	383	1%	S4	G4	NA	
Northern Sedge Meadow	2007	10	231	4%	S3	G4	NA	
Northern Wet Forest	2008	9	322	3%	S4	G4	NA	
Northern Wet-mesic Forest	2007	7	243	3%	S3S4	G3?	NA	
Oak Barrens	2007	4	38	11%	S2	G2?	NA	
Open Bog	1996	5	173	3%	S4	G5	NA	
Pine Barrens	2007	10	56	18%	S2	G2	NA	
Poor Fen	2004	3	46	7%	S3	G3G4	NA	
Sand Barrens	1977	1	29	3%	SU	GNR	NA	
Sand Prairie	2007	1	28	4%	S2	GNR	NA	
Shore Fen	1996	1	11	9%	S2	GNR	NA	
Southern Mesic Forest	2008	3	221	1%	S3	G3?	NA	
Spring Pond	1982	4	69	6%	S3	GNR	NA	
Springs and Spring Runs, Hard	1982	2	71	3%	S4	GNR	NA	
Springs and Spring Runs, Soft	2006	4	12	33%	SU	GNR	NA	
Stream—Fast, Hard, Cold	1996	1	98	1%	S4	GNR	NA	
Stream—Fast, Soft, Cold	1996	1	15	7%	SU	GNR	NA	
Submergent Marsh	1996	1	6	17%	S4	G5	NA	
Tamarack (Poor) Swamp	2004	3	33	9%	S3	G4	NA	
OTHER ELEMENTS								
Bird rookery	1985	1	54	2%	SU	G5	SC	

[a]An element occurrence is an area of land and/or water in which a rare species or natural community is, or was, present. Element occurrences must meet strict criteria that is used by an international network of Heritage programs and coordinated by NatureServe.

[b]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Continued on next page

Appendix 17.C, *continued.*

[c]The American Ornithologist's Union lists these birds as Canada Warbler (*Cardellina canadensis*), Hooded Warbler (*Setophaga citrina*), Kirtland's Warbler (*Setophaga kirtlandii),* Louisiana Waterthrush *(Parkesia motacilla*), and Cape May Warbler *(Setophaga tigrina)*.
[d]Kirtland's Warbler was listed as Wisconsin Endangered in 2015.

STATUS AND RANKING DEFINITIONS

U.S. Status—Current federal protection status designated by the Office of Endangered Species, U.S. Fish and Wildlife Service, indicating the biological status of a species in Wisconsin:

LE = listed endangered.
LT = listed threatened.
PE = proposed as endangered.
NEP = nonessential experimental population.
C = candidate for future listing.
CH = critical habitat.

State Status—Protection category designated by the Wisconsin DNR:

END = Endangered. Endangered species means any species whose continued existence as a viable component of this state's wild animals or wild plants is determined by the Wisconsin DNR to be in jeopardy on the basis of scientific evidence.
THR = Threatened species means any species of wild animals or wild plants that appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered.
SC = Special Concern. Special Concern species are those species about which some problem of abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.
Wisconsin DNR and federal regulations regarding Special Concern species range from full protection to no protection. The current categories and their respective level of protection are as follows:
SC/P = fully protected;
SC/N = no laws regulating use, possession, or harvesting;
SC/H = take regulated by establishment of open closed seasons;
SC/FL = federally protected as endangered or threatened but not so designated by Wisconsin DNR;
SC/M = fully protected by federal and state laws under the Migratory Bird Act.

Global Element Ranks:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state or physiographic region) or because of other factor(s) making it vulnerable to extinction throughout its range; typically 21-100 occurrences.
G4 = Uncommon but not rare (although it may be quite rare in parts of its range, especially at the periphery) and usually widespread. Typically > 100 occurrences.
G5 = Common, widespread, and abundant (although it may be quite rare in parts of its range, especially at the periphery). Not vulnerable in most of its range.
GH = Known only from historical occurrence throughout its range, with the expectation that it may be rediscovered.
GNR = Not ranked. Replaced G? rank and some GU ranks.
GU = Currently unrankable due to lack of data or substantially conflicting data on status or trends. Possibly in peril range-wide, but status is uncertain.
GX = Presumed to be extinct throughout its range (e.g., Passenger pigeon) with virtually no likelihood that it will be rediscovered.

Species with a questionable taxonomic assignment are given a "Q" after the global rank. Subspecies and varieties are given subranks composed of the letter "T" plus a number or letter. The definition of the second character of the subrank parallels that of the full global rank. (Examples: a rare subspecies of a rare species is ranked G1T1; a rare subspecies of a common species is ranked G5T1.)

State Element Ranks:

S1 = Critically imperiled in Wisconsin because of extreme rarity, typically 5 or fewer occurrences and/or very few (<1,000) remaining individuals or acres, or due to some factor(s) making it especially vulnerable to extirpation from the state.
S2 = Imperiled in Wisconsin because of rarity, typically 6–20 occurrences and/or few (1,000– 3,000) remaining individuals or acres, or due to some factor(s) making it very vulnerable to extirpation from the state.
S3 = Rare or uncommon in Wisconsin, typically 21–100 occurrences and/or 3,000–10,000 individuals.
S4 = Apparently secure in Wisconsin, usually with > 100 occurrences and > 10,000 individuals.
S5 = Demonstrably secure in Wisconsin and essentially ineradicable under present conditions.
SNA = Accidental, nonnative, reported but unconfirmed, or falsely reported.
SH = Of historical occurrence in Wisconsin, perhaps having not been verified in the past 20 years and suspected to be still extant. Naturally, an element would become SH without such a 20-year delay if the only known occurrence were destroyed or if it had been extensively and unsuccessfully looked for.
SNR = Not Ranked; a state rank has not yet been assessed.
SU = Currently unrankable. Possibly in peril in the state, but status is uncertain due to lack of information or substantially conflicting data on status or trends.
SX = Apparently extirpated from the state.

State ranking of long-distance migrant animals:

Ranking long distance aerial migrant animals presents special problems relating to the fact that their nonbreeding status (rank) may be quite different from their breeding status, if any, in Wisconsin. In other words, the conservation needs of these taxa may vary between seasons. In order to present a less ambiguous picture of a migrant's status, it is necessary to specify whether the rank refers to the breeding (B) or nonbreeding (N) status of the taxon in question. (e.g., S2B, S5N). (Examples: a rare subspecies of a rare species is ranked G1T1; a rare subspecies of a common species is ranked G5T1.)

Appendix 17.D. *Number of species with special designations documented within the Northwest Sands Ecological Landscape, 2009.*

Listing status[a]	Taxa					Total fauna	Total flora	Total listed
	Mammals	Birds	Herptiles	Fishes	Invertebrates			
U.S. Endangered	1	1	0	0	1	3	0	3
U.S. Threatened	0	0	0	0	0	0	0	0
U.S. Candidate	0	0	0	0	0	0	0	0
Wisconsin Endangered	0	1	0	0	3	4	4	8
Wisconsin Threatened	0	5	2	3	1	11	9	20
Wisconsin Special Concern	4	22	5	3	40	74	33	107
Natural Heritage Inventory total	**4**	**28**	**7**	**6**	**44**	**89**	**46**	**135**

Note: Wisconsin-listed species always include federally listed species (although they may not have the same designation); therefore, federally listed species are not included in the total.

[a]Kirtland's Warbler was listed as Wisconsin Endangered in 2015. This listing is not included in the numbers above.

Appendix 17.E. *Species of Greatest Conservation Need (SGCN) found in the Northwest Sands Ecological Landscape.*

These SGCN have a high or moderate probability of being found in this ecological landscape and use habitats that have the best chance for management here. Data are from the Wisconsin Wildlife Action Plan (WDNR 2005c) and Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3, "Supporting Materials." For more complete and/or detailed information, please see the Wisconsin Wildlife Action Plan. The Wildlife Action Plan is meant to be dynamic and will be periodically updated to reflect new information; the next update is planned for 2015.

Only SGCN highly or moderately (H = high association, M = moderate association) associated with specific community types or other habitat types and that have a high or moderate probability of occurring in the ecological landscape are included here (SGCN with a low affinity with a community type or other habitat type and with low probability of being associated with this ecological landscape were excluded). Only community types designated as "Major" or "Important" management opportunities for the ecological landscape are shown.

Osprey eating fish.
Photo by Len Blumin.

	MAJOR								IMPORTANT											
	Coldwater Streams	Coolwater Streams	Emergent Marsh	Emergent Marsh – Wild Rice	Inland Lakes	Northern Dry Forest	Northern Dry-mesic Forest	Northern Sedge Meadow	Northern Wet Forest	Oak Barrens	Open Bog	Pine Barrens	Submergent Marsh	Surrogate Grasslads	Warmwater Rivers	Alder Thicket	Impoundments/Reservoirs	Northern Hardwood Swamp	Wet-mesic Forest	Warmwater Streams
Species That Are Significantly Associated with the Northwest Sands Ecological Landscape																				
MAMMALS																				
Franklin's ground squirrel										H		H		M						
Gray wolf						M	H		H	M	M	M				H		M	H	
Northern flying squirrel						M	H		H									M	H	
Water shrew	H	H			M				H							M		H	H	M
BIRDS[a]																				
American Bittern			H					H			H									
American Woodcock																H		M		
Bald Eagle					H								M		H		H			
Black Tern			H	M	M			M					M				M			
Black-backed Woodpecker						M			H											
Black-billed Cuckoo										M		M				H				
Blue-winged Teal			H	M	M			M					M	M			M			
Bobolink								H			M			H						
Brown Thrasher										H		H		M						
Connecticut Warbler						H			M		M	M								
Field Sparrow										M		M		M						
Golden-winged Warbler						M	M		M		M					H		M		
Le Conte's Sparrow								H			M			H						
Least Flycatcher						M	M											M		
Lesser Scaup				M	M								H		M		M			
Nelson's Sharp-tailed Sparrow								H												
Northern Harrier								H		M	M	M		H						
Osprey					H										H		H			
Red Crossbill						H	H					M								
Red-headed Woodpecker										M										

Continued on next page

Appendix 17.E, *continued.*


Wood turtle.
Photo by Wisconsin DNR staff.

	MAJOR															IMPORTANT				
	Coldwater Streams	Coolwater Streams	Emergent Marsh	Emergent Marsh – Wild Rice	Inland Lakes	Northern Dry Forest	Northern Dry-mesic Forest	Northern Sedge Meadow	Northern Wet Forest	Oak Barrens	Open Bog	Pine Barrens	Submergent Marsh	Surrogate Grasslads	Warmwater Rivers	Alder Thicket	Impoundments/Reservoirs	Northern Hardwood Swamp	Wet-mesic Forest	Warmwater Streams
Sharp-tailed Grouse								M		H		H		M						
Short-billed Dowitcher			H														M			
Trumpeter Swan			H	H	M								H				M			
Upland Sandpiper										M		M		H						
Veery							M		M							H		H		
Vesper Sparrow										H		H								
Whip-poor-will						M	M			M		M								
Yellow Rail								H			H									
HERPTILES																				
Blanding's turtle	M	M	H	H	H			M		H		H	H		M	M	H			M
Boreal chorus frog			H		H			H		H	H	H					H			
Gophersnake										H		H								
Northern prairie skink						M	M			H		H								
Wood turtle	H	H						M	M	H		H	H		H	H		M	M	H
FISH																				
Banded killifish					M															
Greater redhorse					M										M		M			H
Least darter					M										M					M
Pugnose shiner					M															M
River redhorse															M					
Species That Are Moderately Associated with the Northwest Sands Ecological Landscape																				
MAMMALS																				
Woodland jumping mouse									M									M	M	
BIRDS																				
American Golden Plover			M											M			M			
Blue-winged Warbler																				
Canada Warbler							M		M							M		H	H	
Canvasback				M	M								H		H		M			
Dunlin			M												M		M			
Eastern Meadowlark														H						
Grasshopper Sparrow										M				H						
Hudsonian Godwit			H																	
Marbled Godwit			H											M						
Northern Goshawk							M													
Olive-sided Flycatcher									H		M								M	
Red-necked Grebe			H										M							

Continued on next page

Appendix 17.E, *continued.*


Northern Harrier.
Photo by Brian Collins.

	MAJOR															IMPORTANT				
	Coldwater Streams	Coolwater Streams	Emergent Marsh	Emergent Marsh – Wild Rice	Inland Lakes	Northern Dry Forest	Northern Dry-mesic Forest	Northern Sedge Meadow	Northern Wet Forest	Oak Barrens	Open Bog	Pine Barrens	Submergent Marsh	Surrogate Grasslads	Warmwater Rivers	Alder Thicket	Impoundments/Reservoirs	Northern Hardwood Swamp	Wet-mesic Forest	Warmwater Streams
Red-shouldered Hawk							M													
Rusty Blackbird			M								M					M				
Solitary Sandpiper	M	M	H								M									M
Wilson's Phalarope			H					H					M							
Wood Thrush																				
HERPTILES																				
Four-toed salamander	M	M	H					M	M		H					H		M	H	
Mink frog	M	H	H	M	H			H			H		H		H	M	H			H
Mudpuppy	M				H										H		H			
Pickerel frog	H	H	H		M			H	M		M		H		H	M	H		M	H
FISH																				
Gilt darter															H					H
Lake sturgeon					H										H		H			

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 17.F. *Natural communities[a] for which there are management opportunities in the Northwest Sands Ecological Landscape.*

Major opportunity[b]	Important opportunity[c]	Present[d]
Northern Dry Forest	Northern Wet-mesic Forest	Northern Mesic Forest
Northern Dry-mesic Forest	Northern Hardwood Swamp	Floodplain Forest
Northern Wet Forest (Black Spruce Swamp; Tamarack Swamp)	Alder Thicket	Shrub-carr
Pine Barrens		
Oak Barrens	Impoundment/Reservoir	Oligotrophic Marsh
	Warmwater Stream	Ephemeral Pond
Northern Sedge Meadow		
Surrogate Grasslands		
Open Bog		
Emergent Marsh		
Emergent Marsh – Wild Rice		
Submergent Marsh		
Inland Beach		
Coldwater Stream		
Coolwater Stream		
Inland Lake		
Spring Pond		
Warmwater River		

[a]See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types. Also see Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape" in Part 3 for an explanation on how the information in this table can be used.

[b]Major opportunity – Relatively abundant, represented by multiple significant occurrences, or ecological landscape is appropriate for major restoration activities.

[c]Important opportunity – Less abundant but represented by one to several significant occurrences or type is restricted to one or a few ecological landscapes.

[d]Present – Uncommon or rare, with no good occurrences documented. Better opportunities are known to exist in other ecological landscapes, or opportunities have not been adequately evaluated.

Appendix 17.G. *Public conservation lands in the Northwest Sands Ecological Landscape, 2005.*

Property name	Size (acres)[a]
STATE	
Amsterdam Sloughs State Wildlife Area	5,750
Bean Brook State Fishery Area[b]	1,330
Brule River State Forest[b]	24,500
Clam River State Fishery Area[b]	420
Crex Meadows State Wildlife Area	27,360
Danbury State Wildlife Areab	900
Douglas County State Wildlife Area	980
Fish Lake State Wildlife Area[b]	13,100
Flat Creek State Wildlife Area	370
Governor Knowles State Forest[b]	9710
Kiezer Lake State Wildlife Area	1,385
White River State Fishery Area[b]	1,580
Miscellaneous Lands[c]	3,320
FEDERAL	
Chequamegon-Nicolet National Forest[b]	120,820
St. Croix National Scenic Riverway[b]	30,790
COUNTY FOREST[d]	
Bayfield County Forest[b]	66,590
Burnett County Forest[b]	80,300
Douglas County Forest[b]	73,500
Polk County Forest[b]	10,280
Sawyer County Forest[b]	720
Washburn County Forest[b]	50,310
Namekagon Barrens Wildlife Area	5,000
TOTAL	529,015

Source: *Wisconsin Land Legacy Report* (WDNR 2006b).

[a]Actual acres owned in this ecological landscape.

[b]This property also falls within adjacent ecological landscape(s).

[c]Includes public access sites, fish hatcheries, fire towers, streambank and nonpoint easements, lands acquired under statewide wildlife, fishery, forestry, and natural area programs, Board of Commissioners of Public Lands holdings, small properties under 100 acres, and properties with fewer than 100 acres within this ecological landscape.

[d]Locations and sizes of county-owned parcels enrolled in the Forest Crop Law program are presented here. Information on locations and sizes of other county and local parks in this ecological landscape is not readily available and is not included here, except for some very large properties.

Appendix 17.H. *Land Legacy places in the Northwest Sands Ecological Landscape and their ecological and recreational significance.*

The *Wisconsin Land Legacy Report* (WDNR 2006b) identified 14 places in the Northwest Sands Ecological Landscape that merit conservation attention based upon a combination of ecological significance and recreational potential. Each Legacy place was scored on a relative scale for conservation significance based on ecological quality, rarity, and/or restoration potential (see Wisconsin DNR 2006b, p. 46 for detailed description of the ranking process). Each Legacy place was scored on a relative scale for recreation potential based on the types of opportunities available and accessibility to the state's residents. Scores are based on professional judgment and as such are subjective and are intended to provide managers with a general picture of how these places may meet conservation and recreation needs.

Map Code	Place name	Size	Protection initiated	Protection remaining	Conservation significance[a]	Recreation potential[b]
BB	Bois Brule River	Large	Substantial	Limited	xxxxx	xxxxx
CN	Chequamegon-Nicolet National Forest	Large	Substantial	Limited	xxxxx	xxxxx
CR	Clam River	Medium	Moderate	Substantial	xxx	xxxx
CX	Crex Meadows	Medium	Substantial	Limited	xxxxx	xxxxx
DS	Danbury to Sterling Corridor	Large	Substantial	Moderate	xxxxx	xxx
ER	Eau Claire River	Small	Limited	Moderate	xxx	xx
HW	Highway 2 Grasslands	Small	Limited	Moderate	xx	x
LS	Lake Superior South Shore Streams	Large	Substantial	Moderate	xxx	xxx
LG	Lower Totagatic River	Medium	Moderate	Moderate	xxx	xx
NB	Namekagon - Brule Barrens	Large	Moderate	Moderate	xxxxx	xxx
NR	Namekagon River	Large	Substantial	Limited	xxxxx	xxxx
SX	St. Croix River	Large	Substantial	Limited	xxxxx	xxxx
UY	Upper Yellow River	Small	Moderate	Moderate	xxx	xxx
WR	White River	Large	Moderate	Moderate	xxxx	xx

[a]**Conservation significance.** See the *Wisconsin Land Legacy Report* (WDNR 2006b), p. 43, for detailed discussion.

- xxxxx Possesses outstanding ecological qualities, is large enough to meet the needs of critical components, and/or harbors globally or continentally significant resources. Restoration, if needed, has a high likelihood of success.
- xxxx Possesses excellent ecological qualities, is large enough to meet the needs of most critical components, and/or harbors continentally or Great Lakes regionally significant resources. Restoration has a high likelihood of success.
- xxx Possesses very good ecological qualities, is large enough to meet the needs of some critical components, and/or harbors statewide significant resources. Restoration will typically be important and has a good likelihood of success.
- xx Possesses good ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors statewide or ecological landscape significant resources. Restoration is likely needed and has a good chance of success.
- x Possesses good to average ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors ecological landscape significant resources. Restoration is needed and has a reasonable chance of success.

[b]**Recreation potential.** See the *Wisconsin Land Legacy Report*, p. 43, for detailed discussion.

- xxxxx Outstanding recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet many current and future recreation needs, is large enough to accommodate incompatible activities, could link important recreation areas, and/or is close to state's largest population centers.
- xxxx Excellent recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet several current and future recreation needs, is large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to large population centers.
- xxx Very good recreation potential, could offer a variety of land and/or water-based recreation opportunities, could meet some current and future recreation needs, may be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized to large population centers.
- xx Good to moderate recreation potential, could offer some land and/or water-based recreation opportunities, might meet some current and future recreation needs, may not be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized population centers.
- x Limited recreation potential, could offer a few land and/or water-based recreation opportunities, might meet some current and future recreation needs, is not likely large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to small population centers.

Appendix 17.I. *Importance of economic sectors (based on the number of jobs) within the Northwest Sands Counties compared to the rest of the state.*

Industry	CLMC	CSH	CSP	FT	NCF	NES	NH	NLMC	NWL	NWS	SEGP	SLMC	SWS	SCP	WCR	WP
Agriculture, Fishing & Hunting	0.87	2.14	2.41	2.15	2.15	1.90	0.50	2.71	0.43	1.29	0.76	0.10	4.46	0.87	2.36	2.30
Forest Products & Processing	1.64	0.98	1.83	2.40	3.43	2.20	1.33	1.74	0.41	1.07	0.65	0.32	0.45	1.44	0.96	0.69
Mining	1.08	1.64	0.79	0.79	2.69	3.55	0.91	2.16	0.16	0.34	1.47	0.19	0.62	0.08	0.77	1.21
Utilities	2.44	1.08	0.81	0.39	0.61	0.45	0.58	0.41	1.96	1.76	0.67	0.65	0.81	1.83	1.19	0.51
Construction	1.12	1.02	0.89	0.96	1.14	0.92	2.38	1.08	1.07	1.14	1.08	0.67	0.98	1.13	1.03	1.11
Manufacturing (non-wood)	1.23	1.02	0.74	0.98	0.90	1.37	0.21	1.15	0.49	0.59	1.19	0.87	0.78	0.46	0.77	0.99
Wholesale Trade	0.99	0.63	0.61	0.95	0.62	0.53	0.47	0.60	1.15	0.72	1.16	0.98	0.89	0.76	0.83	0.53
Retail Trade	1.01	1.00	0.99	1.11	1.11	1.00	1.66	1.03	1.30	1.19	1.02	0.80	1.69	1.11	1.11	1.13
Tourism-related	0.99	1.12	0.97	0.86	0.99	1.05	1.51	1.28	1.34	1.41	0.94	1.02	0.78	1.33	1.08	1.12
Transportation & Warehousing	0.95	1.32	2.13	1.40	1.19	1.15	0.80	0.89	3.25	2.15	0.82	0.83	0.74	2.12	1.39	0.99
Information	0.76	0.49	0.69	0.74	0.58	0.68	0.80	0.70	0.38	0.49	1.22	1.11	1.09	0.64	0.62	0.57
Finance & Insurance	1.22	1.31	0.89	0.96	0.56	0.46	0.43	0.48	0.47	0.46	1.04	1.18	0.65	0.45	0.70	0.55
Real Estate, Rental & Leasing	0.84	0.73	0.59	0.60	0.52	0.34	1.37	0.95	0.42	0.50	1.17	1.14	0.47	0.46	0.87	0.66
Pro, Science & Tech Services	0.85	0.53	0.46	0.55	0.41	0.36	0.43	0.45	0.51	0.47	1.04	1.51	0.49	0.47	0.63	0.81
Management	0.80	0.26	0.63	0.54	0.37	0.21	0.17	0.24	0.65	0.47	0.94	1.62	0.08	0.64	0.87	0.45
Admin, Support, Waste, & Remediation	0.99	0.42	0.43	0.46	0.34	0.23	0.61	0.34	0.61	0.43	0.92	1.64	0.58	0.51	0.70	0.63
Private Education	0.86	0.68	0.39	0.42	0.86	0.72	0.87	0.55	0.08	0.12	0.80	1.94	0.09	1.53	0.68	0.55
Health Care & Social Services	0.85	0.88	1.27	1.04	0.82	0.90	0.87	0.84	0.96	0.91	0.83	1.32	0.84	0.99	1.09	0.94
Other Services	1.08	1.32	1.10	1.05	1.10	1.13	1.25	1.19	1.36	1.09	1.06	0.84	1.14	1.13	0.91	1.29
Government	0.78	1.09	1.11	1.03	1.26	1.36	1.08	1.03	1.36	1.54	1.04	0.89	1.15	1.50	1.14	1.21

Source: Based on an economic base analysis (Quintero 2007). Definitions of economic sectors can be found at the U.S. Census Bureau's North American Industry Classification System web page (USCB 2015).

Appendix 17.J. *Scientific names of species mentioned in the text.*

Common name	Scientific name
A rare tiger beetle	*Cicindela patruela patruela*
Alder Flycatcher[a]	*Empidonax alnorum*
Alpine milk-vetch	*Astragalus alpinus*
American badger	*Taxidea taxus*
American basswood	*Tilia americana*
American beaver	*Castor canandensis*
American bison	*Bos bison*
American Bittern	*Botaurus lentiginosus*
American black bear	*Ursus americanus*
American Robin	*Turdus migratorius*
American Woodcock	*Scolopax minor*
Armillalria root rot fungus	*Armillaria* spp.
Arrowhead sweet-colts-foot	*Petasites sagittatus*
Aspens	*Populus* spp.
Aspen heart rot fungus	*Phellinus tremulae*
Aspen Hypoxylon canker fungus	*Hypoxylon mammatum*
Autumnal water-starwort	*Callitriche hermaphroditica*
Bald Eagle	*Haliaeetus leucocephalus*
Black ash	*Fraxinus nigra*
Black spruce	*Picea mariana*
Black Tern	*Chlidonias niger*
Black-backed Woodpecker	*Picoides arcticus*
Blackburnian Warbler	*Setophaga fusca*
Black-throated Green Warbler	*Setophaga virens*
Blanding's turtle	*Emydoidea blandingii*
Blue giant hyssop	*Agastache foeniculum*
Blue Jay	*Cyanocitta cristata*
Blue sucker	*Cycleptus elongatus*
Bluegill	*Lepomis macrochirus*
Blueberries	*Vaccinium* spp.
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue-winged Warbler	*Vermivora cyanoptera*
Bobolink	*Dolichonyx oryzivorus*
Bog bluegrass	*Poa paludigena*
Bronze birch borer	*Agrilus anxius*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Bur oak	*Quercus macrocarpa*
Canada Warbler	*Cardellina canadensis,* listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List
Cape May Warbler	*Setophaga tigrina,* listed as *Dendroica tigrina* on the Wisconsin Natural Heritage Working List
Cerulean Warbler	*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List
Chipping Sparrow	*Spizella passerina*
Coho salmon	*Oncorhynchus kisutch*
Common buckthorn	*Rhamnus cathartica*
Common carp	*Cyprinus carpio*
Common Loon	*Gavia immer*
Common Merganser	*Mergus merganser*
Common Raven	*Corvus corax*
Common reed	*Phragmites australis*
Connecticut Warbler	*Oporornis agilis*
Crinkled hairgrass	*Deschampsia flexuosa*
Curly pondweed	*Potamogeton crispus*

Continued on next page

Appendix 17.J, *continued.*

Common name	Scientific name
Dogwood	*Cornus* spp.
Dotted blazing-star	*Liatris punctata* var. *nebraskana*
Downy phlox	*Phlox pilosa*
Dwarf milkweed	*Asclepias ovalifolia*
Eastern hemlock	*Tsuga canadensis*
Eastern pocket gopher	*Geomys bursarius*
Eastern white pine	*Pinus strobus*
Elk	*Cervus canadensis*
Emerald ash borer	*Agrilus planipennis*
Eurasian honeysuckles	*Lonicera tatarica*, *Lonicera morrowii*, and *Lonicera* x *bella*
Eurasian water-milfoil	*Myriophyllum spicatum*
Evening Grosbeak	*Coccothraustes vespertinus*
Extra-striped snaketail	*Ophiogomphus anomalus*
Fairy-slipper orchid	*Calypso bulbosa*
Fassett's locoweed	*Oxytropis campestris* var. *chartacea*
Fisher	*Martes pennanti*
Flowering-rush	*Butomus umbellatus*
Forest tent caterpillar	*Malacosoma disstria*
Franklin's ground squirrel	*Spermophilus franklinii*
Gilt darter	*Percina evides*
Glossy buckthorn	*Rhamnus frangula*
Golden-winged Warbler	*Vermivora chrysoptera*
Gophersnake	*Pituophis catenifer*
Gray Jay	*Perisoreus canadensis*
Gray wolf	*Canis lupus*
Great Egret	*Ardea alba*
Greater Prairie-chicken	*Tympanuchus cupido*
Greater redhorse	*Moxostoma valenciennesi*
Gypsy moth	*Lymantria dispar*
Hoary elfin	*Callophrys polios*
Hooded Warbler	*Setophaga citrina,* listed as *Wilsonia citrina* on the Wisconsin Natural Heritage Working List
Hooker's orchid	*Platanthera hookeri*
Hybrid cat-tail	*Typha* x *glauca*
Jack pine	*Pinus banksiana*
Jack pine budworm	*Choristoneura pinus*
Karner blue butterfly	*Lycaeides melissa samuelis*
Kirtland's Warbler	*Setophaga kirtlandii,* listed as *Dendroica kirtlandii* on the Wisconsin Natural Heritage Working List
Lake sturgeon	*Acipenser fulvescens*
Lapland azalea	*Rhododendron lapponicum*
Lapland buttercup	*Ranunculus lapponicus*
Large round-leaved orchid	*Platanthera orbiculata*
Large-flowered ground-cherry	*Leucophysalis grandiflora*
Largemouth bass	*Micropterus salmoides*
Le Conte's Sparrow	*Ammodramus leconteii*
Leafy spurge	*Euphorbia esula*
Least Bittern	*Ixobrychus exilis*
Leonard's skipper	*Hesperia leonardus*
Lesser wintergreen	*Pyrola minor*
Lilacs	*Syringa* spp.
Louisiana Waterthrush	*Parkesia motacilla,* listed as *Seiurus motacilla* on the Wisconsin Natural Heritage Working List
Mallard	*Anas platyrhynchos*
Marsh willow-herb	*Epilobium palustre*

Continued on next page

Appendix 17.J, *continued.*

Common name	Scientific name
Marsh Wren	*Cistothorus palustris*
Michaux's sedge	*Carex michauxiana*
Moose	*Alces americanus*
Mourning Warbler	*Geothlypis philadelphia*
Muskellunge	*Esox masquinongy*
Narrow-leaved cat-tail	*Typha angustifolia*
Nashville Warbler	*Oreothlypis ruficapilla*
Nelson's Sparrow	*Ammodramus nelsoni*
North American river otter	*Lontra canadensis*
Northeastern bladderwort	*Utricularia resupinata*
Northern black currant	*Ribes hudsonianum*
Northern Cardinal	*Cardinalis cardinalis*
Northern Harrier	*Circus cyaneus*
Northern Parula	*Setophaga americana*
Northern pike	*Esox lucius*
Northern pin oak	*Quercus ellipsoidalis*
Northern red oak	*Quercus rubra*
Northern Waterthrush	*Parkesia noveboracensis*
Northern white-cedar	*Thuja occidentalis*
Oak	*Quercus* spp.
Oak wilt fungus	*Ceratocystis fagacearum*
Olive-sided Flycatcher	*Contopus cooperi*
Osprey	*Pandion haliaetus*
Peat moss	*Sphagnum* spp.
Phlox moth	*Schinia indiana*
Pine blight fungus	*Diplodia pinea*
Pine sawfly	*Neodiprion* spp.*, Diprion* spp.
Pine Warbler	*Setophaga pinus*
Prairie skink	*Plestiodon septentrionalis*
Privets	*Ligustrum* spp.
Prothonotary Warbler	*Protonotaria citrea*
Pugnose shiner	*Notropis anogenus*
Purple loosestrife	*Lythrum salicaria*
Purple wartyback	*Cyclonaias tuberculata*
Pygmy snaketail	*Ophiogomphus howei*
Quaking aspen	*Populus tremuloides*
Rainbow trout	*Oncorhynchus mykiss*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Red-bellied Woodpecker	*Melanerpes carolinus*
Redhead	*Aythya americana*
Red-necked Grebe	*Podiceps grisegena*
Red-shouldered Hawk	*Buteo lineatus*
Reed canary grass	*Phalaris arundinacea*
Richardson sedge	*Carex richardsonii*
Ring-necked Duck	*Aythya collaris*
River redhorse	*Moxostoma carinatum*
Ruffe	*Gymnocephalus cemuus*
Ruffed Grouse	*Bonasa umbellus*
Rugulose grape fern	*Botrychium rugulosum*
Rusty crayfish	*Orconectes rusticus*
Sandhill Crane	*Grus canadensis*
Scrub oak	*Quercus ellipsoidalis* and *Quercus.* spp.
Sea lamprey	*Petromyzon marinus*
Sedge Wren	*Cistothorus platensis*

Continued on next page

Appendix 17.J, *continued.*

Common name	Scientific name
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Sheathed sedge	*Carex vaginata*
Short-eared Owl	*Asio flammeus*
Silky prairie-clover	*Dalea villosa* var. *villosa*
Slender bulrush	*Schoenoplectus heterochaetus*
Small yellow lady's-slipper	*Cypripedium parviflorum* var. *makasin*
Smallmouth bass	*Micropterus dolomieu*
Smooth green snake	*Opheodrys vernalis*
Snowshoe hare	*Lepus americanus*
Song Sparrow	*Melospiza melodia*
Southern brook lamprey	*Ichthyomyzon gagei*
Speckled alder	*Alnus incana*
Spotted knapweed	*Centaurea biebersteinii*
Spruce Grouse	*Falcipennis canadensis*
St. Croix snaketail	*Ophiogomphus susbehcha*
Sugar maple	*Acer saccharum*
Sweet fern	*Comptonia peregrina*
Tamarack	*Larix laricina*
Torrey's bulrush	*Schoenoplectus torreyi*
Trumpeter Swan	*Cygnus buccinator*
Two-lined chestnut borer	*Agrilus bilineatus*
Veery	*Catharus fuscescens*
Walleye	*Sander vitreus*
Whip-poor-will	*Antrostomus vociferus*
White birch	*Betula papyrifera*
White pine blister rust	*Cronartium ribicola*
White-tailed deer	*Odocoileus virginianus*
White-throated Sparrow	*Zonotrichia albicollis*
Wild lupine	*Lupinus perennis*
Willow	*Salix* spp.
Wilson's Phalarope	*Phalaropus tricolor*
Winter Wren	*Troglodytes hiemalis*
Wood Duck	*Aix sponsa*
Wood turtle	*Glyptemys insculpta*
Woodland caribou	*Rangifer tarandus*
Yellow birch	*Betula alleghaniensis*
Yellow perch	*Perca flavescens*
Yellow Rail	*Coturnicops noveboracensis*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped Warbler	*Setophaga coronata*
Zebra mussel	*Dreissena polymorpha*

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 17.K. *Maps of important physical, ecological, and aquatic features within the Northwest Sands Ecological Landscape.*

- Vegetation of the Northwest Sands Ecological Landscape in the Mid-1800s
- Land Cover of the Northwest Sands Ecological Landscape in the Mid-1800s
- Landtype Associations of the Northwest Sands Ecological Landscape
- Public Land Ownership, Easements, and Private Land Enrolled in the Forest Tax Programs in the Northwest Sands Ecological Landscape
- Ecologically Significant Places of the Northwest Sands Ecological Landscape
- Exceptional and Outstanding Resource Waters and 303(d) Degraded Waters of the Northwest Sands Ecological Landscape
- Dams of the Northwest Sands Ecological Landscape
- WISCLAND Land Cover (1992) of the Northwest Sands Ecological Landscape
- Soil Regions of the Northwest Sands Ecological Landscape
- Relative Tree Density of the Northwest Sands Ecological Landscape in the Mid-1800s
- Population Density, Cities, and Transportation of the Northwest Sands Ecological Landscape

Note: *Go to http://dnr.wi.gov/topic/landscapes/index.asp?mode=detail&Landscape=13 and click the "maps" tab.*

Literature Cited

American Bird Conservancy (ABC). 2014. Globally important bird areas of the United States. Web page. Available online at http://www.abcbirds.org/abcprograms/domestic/iba/index.html.

Austin, H.R. 1964. *The Wisconsin story*. The Journal Company, Milwaukee.

Bernthal, T., and K. Willis. 2004. Using Landsat 7 imagery to map invasive reed canary grass (*Phalaris arundinacea*): a landscape level wetland monitoring methodology. Wisconsin Department of Natural Resources, Final Report to the U.S. EPA, Region V. Wisconsin Department of Natural Resources, Madison.

Brockman, K.M., and R.A. Dow, editors. 1982. *Wildlife in early Wisconsin: a collection of works by A.W. Schorger*. Student Chapter of The Wildlife Society, Stevens Point, Wisconsin.

Cardille, J.A., S.J. Ventura, and M.G. Turner. 2001. Environmental and social factors influencing wildfires in the Upper Midwest, United States. *Ecological Applications* 11(1):111–127.

Clark, J.S. 1990. Fire and climate change during the last 750 years in northwestern Minnesota. *Ecological Monographs* 60(2):135–159.

Clayton, L. 1984. *Pleistocene geology of the Superior Region, Wisconsin*. Wisconsin Geological and Natural History, Survey Information Circular 46, Madison. 40 pp. + map at 1:250,000 scale.

Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. National hierarchical framework of ecological units. Pages 181–200 *in* M.S. Boyce and A. Haney, editors. *Ecosystem management: applications for sustainable forest and wildlife resources*. Yale University Press, New Haven, Connecticut.

Curtis, J.T. 1959. *Vegetation of Wisconsin*. University of Wisconsin Press, Madison.

Cutright, N.J., B.R. Harriman, and R.W. Howe. 2006. *Atlas of the breeding birds of Wisconsin*. Wisconsin Society for Ornithology, Waukesha.

Czarapata, E. 2005. *Invasive plants of the Upper Midwest: an illustrated guide to their identification and control*. University of Wisconsin Press, Madison. 352 pp.

Dickas, A.B. 1992. Geology of the midcontinent rift system along the south shore of Lake Superior, Wisconsin and Michigan. Pages 45–53 *in Proceedings of the Field Trip Guidebook*. Institute on Lake Superior Geology, 38th Annual Meeting, May 6-9, 1992, Hurley, Wisconsin.

Dott, R.H., and J.W. Attig. 2004. *Roadside geology of Wisconsin*. Mountain Press Publishing Company, Missoula, Montana. 345 pp.

Fandel, S.G., and S. Hull. 2011. *Wisconsin Sharp-tailed Grouse: a comprehensive management and conservation strategy*. Wisconsin Department of Natural Resources, Bureau of Science Services, Madison. 68 pp.

Finley, R.W. 1976. *Original vegetation cover of Wisconsin*. Map compiled from U.S. General Land Office notes. University of Wisconsin-Extension, Madison.

Fitzpatrick, F.A., P.J. Garrison, S. Fitzgerald, and J. Elder. 2003. *Nutrient, trace element, and ecological history of Musky Bay, Lac Courte Oreilles, Wisconsin, as inferred from sediment cores*. United States Department of the Interior, U.S. Geological Survey Water Resources Investigations Report 02-4225, Middleton, Wisconsin.

Great Lakes Indian Fish and Wildlife Commission (GLIFWC). 2014a. *Purple loosestrife occurrence and control.* Maps. Available online at maps.glifwc.org, "invasive species" tab to "occurrence" and "control" tabs.

Great Lakes Indian Fish and Wildlife Commission (GLIFWC). 2014b. Rice abundance information for Manoomin waters. Web page. Available online at https://data.glifwc.org/manoomin.harvest.info/ or http://www.glifwc.org/, "wild rice (Manoomin)" link, to "Manoomin harvest outlook and regulations" link.

Great Lakes Indian Fish and Wildlife Commission (GLIFWC). 2014c. *Tribal habitat restoration and invasive species control: Midwest region*. Great Lakes Indian Fish and Wildlife Commission, Great Lakes Restoration Initiative, Circle of Flight Program, Odanah, Wisconsin. Available online at http://www.glifwc.org/publications/pdf/2013HabitatRestoration.pdf or http://www.glifwc.org/, "education materials" tab.

Great Lakes Intertribal Council, Inc (GLITC). 2014. St. Croix Band of Lake Superior Chippewa Indians. Web page. Available online at http://www.glitc.org/tribes/stcroix.

Greb, S.R, J.A. Pike, and D.J. Graczyk. 1999. *Water quality impacts of small impoundments: a pilot study including the evaluation of a landscape-scale temperature model.* Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, Final report for U.S. EPA grant CD995591-01, Madison.

Gregg, L. 1987. *Recommendations for a program of sharptail habitat preservation in Wisconsin.* Wisconsin Department of Natural Resources, Research Report 141, PUBL-SS-541 1987, Madison.

Gregg, L.E., and N. Niemuth. 2000. The history, status, and future of Sharp-Tailed Grouse in Wisconsin. *The Passenger Pigeon* 62(2):158–174.

Hoffman, R., and K. Kearns. 1997. *Wisconsin manual of control recommendations for ecologically invasive plants*. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Madison. 102 pp.

Inter-university Consortium for Political and Social Research (ICPSR). 2007. United States historical census data browser. Available online at http://mapserver.lib.virginia.edu or http://www.icpsr.umich.edu/.

Jackson, H.T. 1961. *Mammals of Wisconsin*. University of Wisconsin Press, Madison. 520 pp.

Johnson, K.M., and C.L. Beale. 2002. Nonmetro recreation routines: their identification and rapid growth. *Rural America* 17(4):12–19.

Johnson, M.D. 2000. *Pleistocene geology of Polk County, Wisconsin*. Wisconsin Geological and Natural History Survey, Bulletin 92, Madison.

Kotar J., J.A. Kovach, and C.T. Locey. 1988. *Field guide to forest habitat types of northern Wisconsin*. University of Wisconsin-Madison, Department of Forestry, and Wisconsin Department of Natural Resources, Madison.

Kotar, J., J.A. Kovach, and T.L. Burger. 2002. *A guide to forest communities and habitat types of northern Wisconsin*. Second edition. University of Wisconsin-Madison, Department of Forest Ecology and Management, Madison.

Kreitinger, K., Y. Steele, and A. Paulios, editors. 2013. The Wisconsin All-bird Conservation Plan, Version 2.0. Wisconsin Department of Natural Resources, Wisconsin Bird Conservation Initiative, Madison. Available online at http://www.wisconsinbirds.org/plan/index.htm.

LaBerge, G.L. 1994. *Geology of the Lake Superior region*. Penokean Press, Oshkosh, Wisconsin.

Lake Classification Advisory Committee (LCAC). 1999. *A guide for county lake classification.* University of Wisconsin-Extension, Wisconsin Department of Natural Resources, and The Lakes Partnership/Wisconsin Association of Lakes, Madison.

Macholl, J.A. 2007. *Inventory of Wisconsin's springs.* Wisconsin Geological and Natural History Survey, Open-File Report 2007-03, Madison.

Manies K.L., and D.J. Mladenoff. 2000. Testing methods to produce landscape-scale presettlement vegetation maps from the U.S. public land survey records. *Landscape Ecology* 15:741–754.

Marcouiller, D., and X. Xia. 2008. Distribution of income from tourism-sensitive employment. *Tourism Economics* 14(3):545–565.

Mason, C.I. 1988. *Introduction to Wisconsin Indians: prehistory to statehood*. Sheffield Publishing, Salem, Wisconsin. 327 pp.

Martin, L. 1965. *The physical geography of Wisconsin.* Third edition. The University of Wisconsin Press, Madison. 608 pp.

Matula, C. 2005. *Brule River State Forest 2000 hail storm–the aftermath*: *2005 annual hail damage monitoring report*. Wisconsin Department of Natural Resources, Madison. Available online at http://www.d.umn.edu/~isak0022/5230/Glocal/nature2005.html.htm.

Minnesota IMPLAN Group Inc. (MIG). 2009. IMPLAN data. Available online at https://implan.com. Accessed August 2009. Accessed April 2009.

Mossman, M.J. 1991. Breeding birds of the St. Croix River, Wisconsin and Minnesota. *The Passenger Pigeon* 53(1):39–78.

National Association of Counties (NACO). 2010. Website. Available online at http://www.naco.org. Accessed August 2010.

Niemuth, N. 2006. Sharp-tailed Grouse (*Tympanuchus phasianellus*). *In* N.J. Cutright, B.R. Harriman, and R.W. Howe. *Atlas of the Breeding Birds of Wis-*

consin. Wisconsin Society for Ornithology, Waukesha, Wisconsin. 602 pp.

Northwest Regional Planning Commission (NWRPC) and Wisconsin Department of Natural Resources (WDNR). 2000. *Northwest Sands landscape level management plan*. Wisconsin Department of Natural Resources, Spooner, Wisconsin.

Ostrom, M.E. 1983. *Thickness of unconsolidated material in Wisconsin*. Map. University of Wisconsin–Extension, Geological and Natural History Survey, Madison.

Quintero, J. 2007. Regional economic development: an economic base study and shift and shares analysis of Hays County, Texas. Texas State University, Applied Research Projects, Paper 259, San Marcos, Texas. Available online at https://digital.library.txstate.edu/handle/10877/3656.

Radeloff, V.C. 2000. Effect of interacting disturbance on landscape pattern: budworm defoliation and salvage logging. *Ecological Applications* 10(1):233–247.

Radeloff, V.C., D.J. Mladeoff, and M.S. Boyce. 2000. A historical perspective and future outlook on landscape scale restoration in the northwest Wisconsin pine barrens. *Restoration Ecology* 8(2):119–126.

Radeloff, V.C., D.J. Mladenoff, K.L. Manies, and M.S. Boyce. 1998. Analyzing forest landscape restoration potential: pre-settlement and current distribution of oak in the northwest Wisconsin pine barrens. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 86:189–206.

Roth, F. 1898. *Forestry conditions and interests of Wisconsin*. With a discussion by B.E. Fernow. U.S. Department of Agriculture, Division of Forestry, Bulletin No. 16, Washington, D.C. 76 pp.

Sample, D.W., and M.J. Mossman. 1997. *Managing habitat for grassland birds: a guide for Wisconsin*. Wisconsin Department of Natural Resources, Bureau of Integrated Science Services, PUBL-SS-925-97, Madison. 154 pp.

Schorger, A.W. 1937. The range of the bison in Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 30:117–130. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1937.

Schorger, A.W. 1942. Extinct and endangered mammals and birds of the upper Great Lakes region. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 34:23–44. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1942.

Schorger, A.W. 1943. The prairie chicken and sharp-tailed grouse in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 35:1–59. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1943.

Schorger, A.W. 1953. The white-tailed deer in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 42:197–247. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1953.

Schorger, A. W. 1956. The moose in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 45:1–10. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1956.

Schorger, A.W. 1965. The beaver in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 54:147–179. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1965.

Schreiber, K. 1993. *Biomonitoring below two commercial cranberry marshes in Jackson County, Wisconsin.* Wisconsin Department of Natural Resources, West Central Region, Eau Claire. 11 pp.

Schulte, L.A., and D.J. Mladenoff. 2001. The original U.S. public land survey records: their use and limitations in reconstructing presettlement vegetation. *Journal of Forestry* 99:5–10.

Stevenson, K.P., R.F. Boszhardt, C.R. Moffat, P.H. Salkin, T.C. Pleger, J.L. Theler, and C.M. Arzigian. 1997. The Woodland Tradition. *The Wisconsin Archaeologist* 78(1–2):140–201.

The Wisconsin Cartographer's Guild. 1998. *Wisconsin's past and present: a historical atlas.* The University of Wisconsin Press, Madison. 144 pp.

Tu, M., C. Hurd, and J.M. Randall. 2001. *Weed control methods handbook: tools and techniques for use in natural areas*. The Nature Conservancy, Wildlife Invasives Species Team, Arlington, Virginia. Available online through the Center for Invasive Species and Ecosystem Health, http://www.invasive.org, keywords "weed control methods handbook." Accessed September 2012.

U.S. Census Bureau (USCB). 2009. U.S. Census Bureau website. Available online at http://www.census.gov. Accessed April 2009.

U.S. Census Bureau (USCB). 2012. 2010 census data: state and county quick facts. Available online at http://quickfacts.census.gov/qfd/states/55000.html. Accessed February 2012.

U.S. Census Bureau (USCB). 2015. North American Industry Classification System. Web page. Available online at http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2012a. 2004 county typology codes. Available online at http://www.ers.usda.gov, keywords "county typology codes." Last updated July 5, 2012.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2012b. Urban influence codes for U.S. counties, 2003. Available online at http://www.ers.usda.gov, keywords "urban influence codes." Last updated July 5, 2012.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2004. 2002 census of agriculture: Wisconsin state and county data. Volume 1, Chapter 2: county level data. Table 1, county summary highlights: 2002. Available online at http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_County_Level/Wisconsin/.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2009. 2007 Census of Agriculture: Wisconsin state and county data. Volume 1, Chapter 2: county level data. Table 1: County summary highlights: 2007. Available online at http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Wisconsin/. Accessed December 2010.

U.S. Department of Commerce, Bureau of Economic Analysis (USDC BEA). 2006. Regional accounts data: local area personal income. Available online at http://www.bea.gov/regional/. Accessed August 2009.

U.S. Department of Energy (USDE). 2014. *Wisconsin 50-meter wind power.* Map. Web page. Available online at http://www.windpoweringamerica.gov/maps_template.asp?stateab=wi.

U.S. Department of Labor, Bureau of Labor Statistics (USDL BLS). 2006. Local area unemployment statistics data. Website. Available online at http://stats.bls.gov. Accessed July 2009.

U.S. Forest Service (USFS). 2004. Forest Inventory and Analysis, Mapmaker, Version 1.0. Accessed October 2007. *(Note: USFS has discontinued the Forest Inventory and Analysis Mapmaker program. See the U.S. Forest Service's "Data and tools" web page, http://www.nrs.fs.fed.us/fia/data-tools/mapping-tools/ and the Forest Inventory Data Online (FIDO) database, http://apps.fs.fed.us/fia/fido/index.html.)*

U.S. Forest Service (USFS). 2007. Forest inventory and analysis, timber product output mapmaker, Version 1.0. Available online at http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php. (*Note: USFS has discontinued the Timber Product Output Mapmaker program. See the U.S. Forest Service's "Data and tools" web page, http://www.nrs.fs.fed.us/fia/data-tools/mapping-tools/ and the Forest Inventory Data Online database, and the Forest Inventory Data Online (FIDO) database, http://apps.fs.fed.us/fia/fido/index.html.*) Accessed October 2007.

U.S. Forest Service (USFS). 2009. Forest Inventory and Analysis, Mapmaker, Version 4.0. Accessed July 2009. (*Note: USFS has discontinued the Timber Product Output Mapmaker program. See the U.S. Forest Service's "Data and tools" web page, http://www.nrs.fs.fed.us/fia/data-tools/mapping-tools/ and the Forest Inventory Data Online (FIDO) database, http://apps.fs.fed.us/fia/fido/index.html.)*

U.S. Forest Service (USFS). 2014. Forest health and economics. Web page. Available online at http://na.fs.fed.us/fhp/index.shtm.

U.S. Geological Survey (USGS). 2010. Estimated use of water in the United States in 2005: county-level data. Web page. Available online at http://water.usgs.gov/watuse/data/2005/index.html. Accessed December 2010.

Weber S. 1993. Jack pine budworm and the Wisconsin pine barrens. Page 8 *in* E.A. Borgerding, G.A. Bartelt, and W.M. McCown, editors. *The future of pine barrens in northwest Wisconsin: a workshop summary.* Wisconsin Department of Natural Resources, PUBL-RF-913-94, Madison.

Wirth, K.R., W.S. Cordua, W.F. Kean, M. Middleton, and Z.J. Naiman. 1998. Field guide to the geology of the southeastern portion of the midcontinent rift system, eastern Minnesota and western Wisconsin. Pages 31-75 *in*

Proceedings of the Field Trip Guidebook. Institute on Lake Superior Geology, 44th Annual Meeting, 6–10 May 1998, Minneapolis.

Wisconsin Commercial Ports Association (WCPA). 2010. Wisconsin ports. Web page. Available online at http://www.wcpaports.org/ports. Accessed December 2010.

Wisconsin Department of Administration (WDOA). 2000. Wisconsin roads 2000 TIGER line files (data set). Wisconsin Department of Administration, Office of Land Information Services, Madison. Accessed December 2010.

Wisconsin Department of Administration (WDOA). 2006. *Wisconsin energy statistics, 2006.* Wisconsin Department of Administration, Division of Energy, Madison. 150 pp. Available online at http://www.doa.state.wi.us/, keywords "energy statistics."

Wisconsin Department of Agriculture, Trade, and Consumer Protection (WDATCP). 2015. Wisconsin's emerald Ash borer information source. Website. Available online at http://datcpservices.wisconsin.gov/eab/article.jsp?topicid=25.

Wisconsin Department of Wisconsin (WDNR). 1993. WISCLAND land cover data. Available online at http://dnr.wi.gov, keyword "WISCLAND." Accessed December 2009.

Wisconsin Department of Natural Resources (WDNR). 1996. *Upper Chippewa River basin water quality management plan: a five year plan to protect and enhance our water resources*. Wisconsin Department of Natural Resources, PUBL-WR-345-96-REV, Madison.

Wisconsin Department of Natural Resources (WDNR). 1999a. *Lake Superior basin water quality management plan.* Wisconsin Department of Natural Resources PUBL-WT-278-99-REV, Madison.

Wisconsin Department of Natural Resources (WDNR). 1999b. *Wisconsin wolf management plan.* Wisconsin Department of Natural Resources, PUBL-ER-099 99, Madison. Available online at http://dnr.wi.gov, keywords "wolf management." Accessed November 2009.

Wisconsin Department of Natural Resources (WDNR). 2001. *Influences of the addition of large woody debris to coldwater streams on anadromous salmonid populations.* Wisconsin Department of Natural Resources, Final report October 2001, Madison.

Wisconsin Department of Natural Resources (WDNR). 2002. *The state of the St. Croix River basin.* Wisconsin Department of Natural Resources, PUBL-WT-555-2002, Madison. Available online at http://dnr.wi.gov/water/basin/stcroix/stcroix_final_3-26-02.pdf or http://dnr.wi.gov, keywords "gateway to basins," St. Croix River basin "plans" tab. Accessed June 1, 2009.

Wisconsin Department of Natural Resources (WDNR). 2005a. Wisconsin DNR managed lands – "dissolved" version. Wisconsin Department of Natural Resources, Madison. See Wisconsin DNR managed lands web mapping application for current database, available at http://dnr.wi.gov/topic/Lands/DMLmap/ or http://dnr.wi.gov, keywords "public access lands."

Wisconsin Department of Natural Resources (WDNR). 2005b. *Wisconsin Lake Superior basin brook trout plan*. Wisconsin Department of Natural Resources and U.S. Fish and Wildlife Service, Madison. 44 pp. Available online at http://dnr.wi.gov/topic/fishing/documents/lakesuperior/LakeSupBrookTroutPlan2005.pdf or http://dnr.wi.gov, keywords "brook trout plan."

Wisconsin Department of Natural Resources (WDNR). 2005c. *Wisconsin strategy for wildlife species of greatest conservation need*. Wisconsin Department of Natural Resources, Wisconsin Wildlife Action Plan, PUB-ER-641-2005, Madison. Available online at http://dnr.wi.gov, keywords "wildlife action plan."

Wisconsin Department of Natural Resources (WDNR). 2006a. *The 2005–2010 Wisconsin statewide comprehensive outdoor recreation plan* (SCORP). Wisconsin Department of Natural Resources, PUB-PR-026-2006, Madison. Available online at http://dnr.wi.gov, keyword "SCORP."

Wisconsin Department of Natural Resources (WDNR). 2006b. *Wisconsin land legacy report: an inventory of places to meet conservation and recreation needs*. Wisconsin Department of Natural Resources, PUB-LF-040-2006, Madison. 247 pp. Available online at http://dnr.wi.gov, keywords "land legacy."

Wisconsin Department of Natural Resources (WDNR). 2008. Managed Forest Law stumpage rates. These data are available by request from the forest tax program, Wisconsin DNR, Madison.

Wisconsin Department of Natural Resources (WDNR). 2009a. *Wisconsin lakes*. Wisconsin Department of Natural Resources, Bureau of Fisheries and Habitat Management, PUB-FM-800 2009, Madison.

Wisconsin Department of Natural Resources (WDNR). 2009. *Wisconsin Natural Heritage Working List.* April 2009. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Madison. Accessed March 11, 2010. Current Working List available online at http://dnr.wi.gov/, keyword "NHI." (*Note: The Wisconsin Natural Heritage Working List is dynamic and updated periodically as new information is available. The April 2009 Working List was used for this book. Those with questions regarding species or natural communities on the Working List should contact Julie Bleser, Natural Heritage Inventory Data Manager, Bureau of Natural Heritage Conservation, Wisconsin DNR at (608) 266-7308 or julie.bleser@wisconsin.gov.*)

Wisconsin Department of Natural Resources (WDNR). 2010a. Impaired waters. Web page. Available online at http://dnr.wi.gov, keywords "impaired waters list." Accessed September 2010.

Wisconsin Department of Natural Resources (WDNR). 2010b. *Wisconsin statewide Karner blue butterfly habitat conservation plan*. Wisconsin Department of Natural Resources, PUBL-SS-947 2010 REV., Madison. Available online at http://dnr.wi.gov/topic/ForestPlanning/documents/KBB-HCP-Final-052710.pdf or http://dnr.wi.gov, keywords "Karner blue conservation plan."

Wisconsin Department of Natural Resources (WDNR). 2010c. Wisconsin Wetland Inventory. Web page. Available online at http://dnr.wi.gov/, keywords "wetland inventory." Accessed September 2010.

Wisconsin Department of Natural Resources (WDNR). 2014a. Forest health. Web page. Available online at http://dnr.wi.gov, keywords "forest health.

Wisconsin Department of Natural Resources (WDNR). 2014b. Hydrography geodatabase. Web page. Available online at http://dnr.wi.gov, keywords "hydrography geodatabase."

Wisconsin Department of Natural Resources (WDNR). 2014c. Invasive species. Web page. Available online at http://dnr.wi.gov/, keywords "invasive species."

Wisconsin Department of Natural Resources (WDNR). 2014d. Outstanding and Exceptional Resource Waters. Web page. Available online at http://dnr.wi.gov, keywords "ORW/ERW."

Wisconsin Department of Natural Resources (WDNR). 2014e. State Natural Areas program. Web page. Available online at http://dnr.wi.gov/, keywords "state natural areas."

Wisconsin Department of Transportation (WDOT). 1998. 1:100,000-scale Rails Chain Database. Wisconsin Department of Transportation, Bureau of Planning, Madison. Accessed December 2010.

Wisconsin Department of Transportation (WDOT). 2012. Wisconsin airport directory 2011–2012. Web page. Available online at http://wisconsindot.gov/Pages/home.aspx, keywords "airport directory."

Wisconsin Geological and Natural History Survey (WGNHS). 2006. *Bedrock stratigraphic units in Wisconsin*. Wisconsin Geological and Natural History Survey, Open-File Report 2006-06, Madison.

Wisconsin Landtype Association (WLTA) Project Team. 2002. *Landtype Associations of Wisconsin*. Wisconsin Department of Natural Resources, Madison. Map at 1:500,000 scale.

Wisconsin State Climatology Office (WSCO). 2011. Climate summaries by location. Retrieved April 29, 2011, from http://www.aos.wisc.edu/~sco/, "past Wisconsin climate" tab to "daily data from National Weather Service reporting stations."

Wisconsin Wind Information Center (WWIC). 2014. Wisconsin wind project information: commercial wind energy installations in Wisconsin 1998–2013. Web page. Available online at http://www.wiwindinfo.net/, "Projects" link.

Wydeven, A.P., J.E. Wiedenhoeft, and J. Bruner. 2012. *Gray wolf population*. Wisconsin Department of Natural Resources, Wildlife Report, Madison.

Additional References

Eckstein, R. 2001. *Wisconsin's northern state forest assessments: community restoration and old growth on the Brule River State Forest*. Wisconsin Department of Natural Resources, PUBL-FR-139a, Madison.

Epstein, E., W. Smith, J. Dobberpuhl, and A. Galvin. 1999. *Biotic inventory and analysis of the Brule River State Forest*. Wisconsin Department of Natural Resources, PUB ER-799 1999, Madison.

Great Lakes Indian Fish and Wildlife Commission (GLIFWC). 2014. Gathering and wild rice harvest regulation summary. Available online at http://www.glifwc.org/Regulations/GatheringandRice_91614.pdf or http://www.glifwc.org/, "harvest regulations" tab.

Kirk, K. 1996. *The Karner blue community: understanding and protecting associated rare species of the barrens*. Wisconsin Department of Natural Resources, Final report to the U.S. Fish and Wildlife Service Amendment 38 to Cooperative Agreement #14-16-0003-89-933, Madison.

Vogl, R.J. 1970. Fire and the northern Wisconsin pine barrens. *Proceedings of the Tall Timbers Fire Ecology Conference* 10:175–209.

Wisconsin Department of Natural Resources. 1999. *Wisconsin Northern State Forest Regional Ecological Assessment*. Wisconsin Department of Natural Resources, PUBL-FR-135-99, Madison.

Wisconsin Department of Natural Resources. 2000. *Deer management for 2000 and beyond – final report of the forestry and ecological issues study group.* Wisconsin Department of Natural Resources and Wisconsin Conservation Congress, Madison.

Wisconsin Department of Natural Resources. 2015. Wisconsin Lakes Partnership: county list of lakes. Available online at http://dnr.wi.gov/lakes/lakespartnership/ or http://dnr.wi.gov, keyword "lakes."

Wisconsin Department of Natural Resources. 2013. *Silviculture and forest aesthetics handbook*, 2431.5, Wisconsin Department of Natural Resources, Madison. Available online at http://dnr.wi.gov, keywords "silviculture handbook."

Acknowledgments

John Lyons provided much needed expertise and advice on fish and aquatic ecology and provided technical review of the aquatic sections.

Julie Bleser interpreted Natural Heritage Inventory data, provided tables of endangered, threatened, and special concern species, and made distribution maps of rare species and natural community occurrences.

Peter David (Great Lakes Indian Fish and Wildlife Commission) provided data on wild rice lakes in the Ceded Territories as well as many useful comments.

Dr. James B. Stoltman (UW-Madison Emeritus Professor of Archeology) provided invaluable information, advice, and consultation on the text on American Indian history.

David Hvizdak, Massachusetts state soil scientist, formerly Natural Resources Conservation Service Major Land Resource Areas project coordinator in northwest Wisconsin, provided information on soils and glacial geology.

Yoyi Steele provided the shapefiles for Important Bird Areas.

Mitch Moline, Kate Barrett, Bill Shockley, Nina Janicki, Sally Dahir, Kathy Hanson, Elizabeth Spencer, and Jennifer Skoloda performed GIS analyses, prepared maps, and provided other background materials.

Sarah Herrick and Jescie Kitchell provided editorial assistance and compiled data and other needed materials for this document.

Technical review for this chapter was provided by John Lyons (Wisconsin DNR-Science Services), Joe Kovach (Wisconsin DNR-Forestry), Pat Trochlell (Wisconsin DNR-Watershed Management), Jan Hacker (Northwest Regional Planning Commission), Linda Parker (Chequamegon-Nicolet National Forest), Dave Marcouiller (University of Wisconsin-MadIson), Jeff Prey (Wisconsin DNR-Parks), and Paul Kookier (Wisconsin DNR-Wildlife Management).

Detailed discussions on various topics covered by this book, including some that were pertinent to this chapter, were held with Andy Paulios, Mike Mossman, Bill (William A.) Smith, Sumner Matteson, Tom Bernthal, Pat Trochlell, Matt Dallman, and Randy Hoffman.

Sarah Hurley, Signe Holtz, Darrell Zastrow, Paul DeLong, Laurie Osterndorf, Mark Aquino, Jack Sullivan, Karl Martin, and Steve Miller provided important administrative support for the project.

Funding

Funding for this project and publication of this report was provided by the Wisconsin Department of Natural Resources Divisions of Forestry, Lands, and Enforcement and Science; by grants from the Wisconsin Wildlife Action Plan Fund; and in part by funds from the Federal Aid to Wildlife Restoration Act under Pittman-Robertson Project W-160-P.

Authors

This chapter was authored by the Wisconsin Department of Natural Resources Ecosystem Management Planning Team members Jerry Bartelt, Owen Boyle, Eric Epstein, Vern Everson, Drew Feldkirchner, Colleen Matula, Eunice Padley, Jeff Schimpff, and Andy Stoltman. See "About the Authors" in Part 3, "Supporting Materials," for a description of team member expertise and experience.

Contributors

Important technical reviews, data interpretation, and editing were done by Wisconsin Department of Natural Resources Ecosystem Management Planning Team members Cathy Bleser and Lisa Helmuth on various topics covered by this book, including some that were pertinent to the Northwest Sands Ecological Landscape. Joe Kovach wrote the section on forest habitat types and provided Table 17.2 for this ecological landscape as well as many useful comments. Sally Dahir analyzed data and wrote sections on socioeconomic resource characterization. Luke Saunders analyzed data and wrote sections on current socioeconomic conditions. Dawn Hinebaugh provided maps and other information on the Wisconsin DNR's State Natural Areas program.

Credits

Publication assistance was provided by Dreux Watermolen. Patricia Duyfhuizen provided the edit, organizational advice, graphic design, and technical layout as well as many other helpful editing suggestions. Michelle Voss developed the graphs and provided assistance with other figures. Andy Stoltman, Wisconsin DNR-Forestry, produced the maps and prepared other cartographic presentations found in this publication.

Sources of photographs include the following: Jerry Bartelt, Wisconsin DNR; Armund Bartz, Wisconsin DNR; Jack Bartholmai; Len Blumin; Brian Collins; Eric Epstein, Wisconsin DNR; J. Grahn; Robert Hanson, Wisconsin DNR; John and Karen Hollingsworth, courtesy of U.S. Fish and Wildlife Service; Dennis Malueg; Mark Martin, Wisconsin DNR; Mike Mossman, Wisconsin DNR; Thomas Meyer, Wisconsin DNR; Colin Nowaczyk; Eunice Padley, Wisconsin DNR; Andy Reago and Chrissy McClarren; Gregor Schuurman, Wisconsin DNR; Dominic Sherony; A.B. Sheldon; William E. Tans; N.L. Taylor; University of Minnesota Press; U.S. Fish and Wildlife Service; Wisconsin DNR staff; and Gary Zahm.

Sources of illustrations include the following: Wisconsin Academy of Sciences, Arts and Letters; Wisconsin Department of Natural Resources.

Printed on recycled paper

Wisconsin Department of Natural Resources
P.O. Box 7921, Madison, WI 53707

PUB-SS-1131S 2015